STANDARD

ANSI/ASHRAE Standard 15-2019
(Supersedes ANSI/ASHRAE Standard 15-2016)
Includes ANSI/ASHRAE addenda listed in Appendix G

Safety Standard for Refrigeration Systems

See Appendix G for approval dates by ASHRAE and the American National Standards Institute.

This Standard is under continuous maintenance by a Standing Standard Project Committee (SSPC) for which the Standards Committee has established a documented program for regular publication of addenda or revisions, including procedures for timely, documented, consensus action on requests for change to any part of the Standard. Instructions for how to submit a change can be found on the ASHRAE® website (https://www.ashrae.org/continuous-maintenance).

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and 9.1, Large Building Air-Conditioning Systems
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b. participation in the next review of the Standard,
c. offering constructive criticism for improving the Standard, or
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ANSI/ASHRAE Standard 15-2019
Safety Standard for Refrigeration Systems

NOTE

Approved addenda, errata, or interpretations for this standard can be downloaded free of charge from the ASHRAE website at www.ashrae.org/technology.

(This foreword is not part of this standard. It is merely informative and does not contain requirements necessary for conformance to the standard. It has not been processed according to the ANSI requirements for a standard and may contain material that has not been subject to public review or a consensus process. Unresolved objectors on informative material are not offered the right to appeal at ASHRAE or ANSI.)

FOREWORD

The 2019 edition of ASHRAE Standard 15 incorporates changes intended to ensure improvement in the safe design, construction, installation, and operation of refrigeration systems. Highlights include deferral to IIAR2 for R-717 ammonia systems (Addendum a); introduction of requirements specific to Low Global Warming Potential (Low GWP) A2L refrigerants (Addenda d and h); changes to restrictions for small, self-contained systems with higher-flammability refrigerants (Addendum b); low-probability pumps (Addendum b); and requirements when changing the refrigerant (Addendum e). Additional changes are noted in Informative Appendix G.

Standard 15 is regularly updated through the continuous maintenance process, which allows additions and modifications based on feedback from users in accordance with ASHRAE's ANSI-approved procedures. In addition to feedback from users, changes in the science originating from ASHRAE and industry research, as well as changes in refrigeration technology, necessitate the continuous maintenance approach. Instructions for how to submit a change can be found on the ASHRAE website at https://www.ashrae.org/continuous-maintenance.

ASHRAE Standard 15 must be used with its companion standard, ANSI/ASHRAE Standard 34, Designation and Safety Classification of Refrigerants*. Standard 34 prescribes the Refrigerant Classification System, as well as refrigerant concentration limits (RCL), which are vitally important in applying this standard. Although changes to Standard 15 are closely coordinated with those to Standard 34, users of Standard 15 should also review the most recent version of Standard 34 and its associated addenda for the latest information related to refrigerant designations and safety classifications.*

ASHRAE Standard 15 gives a method for determining the amount of refrigerant in a given space that, when exceeded, requires a machinery room. When a refrigerant is not classified in ASHRAE Standard 34 or its addenda, it is the responsibility of the owner of a refrigerating system to make this judgment.

ASHRAE Standard 15 is directed toward the safety of persons and property on or near the premises where refrigeration facilities are located. It includes specifications for fabrication of refrigerating systems but does not address the effects of refrigerant emissions on the environment. For information on the environmental effects of refrigerant emissions, see ANSI/ASHRAE Standard 147, Reducing the Release of Halogenated Refrigerants from Refrigerating and Air-Conditioning Equipment and Systems*.*

The hazards of refrigerants are related to their physical and chemical characteristics and to the pressures and temperatures that occur in refrigerating and air-conditioning systems. Personal injury and property damage from inadequate precautions may originate in a number of ways:

- *Risk of flying debris from a ruptured part*
- *Release of refrigerant from a fracture, due to a leaking seal or incorrect operation*
- *Fire resulting from or intensified by burning or deflagration of escaping refrigerant or lubricant*

Personal injury resulting from the accidental release of refrigerants may also occur from the following:

- *Suffocation from heavier-than-air refrigerants in inadequately ventilated spaces*
- *Narcotic and cardiac sensitization effects*
- *Toxic effects of vapor or the decomposition products due to vapor contact with flames or hot surfaces*
- *Corrosive attack on the eyes, skin, or other tissue*
- *Freezing of tissue by contact with liquid*

Care should be taken to avoid stagnant pockets of refrigerant vapors by properly locating ventilation supply air inlets and exhaust outlets. All commonly used refrigerants, except ammonia (R-717) and water (R-718), are heavier than air. Leaked refrigerant vapor will concentrate near the floor if undisturbed. Floor-level exhaust-air outlets are appropriate for heavier-than-air refrigerants.

Users of ASHRAE Standard 15 may refer to the Standard 15-2001 User's Manual*. The user's manual was developed as a companion document to ASHRAE Standard 15. Though it does not reflect the more recent changes to the standard, it still serves to clarify the intent of many of the standard's provisions and provides some explanation of the rationale behind them. Also included are illustrations and examples of accepted industry practice, as well as explanations of and supporting references for formulas in the standard. The user's manual also covers building, system, and refrigerant classifications, restrictions on refrigerant use, installation restrictions, and equipment and system design and construction for commercial, residential, and industrial applications.*

1. PURPOSE

This standard specifies safe design, construction, installation, and operation of refrigeration systems.

2. SCOPE

2.1 This standard establishes safeguards for life, limb, health, and property and prescribes safety requirements.

2.2 This standard applies to

a. the design, construction, test, installation, operation, and inspection of mechanical and absorption refrigeration systems, including *heat-pump* systems used in stationary applications;
b. modifications, including replacement of parts or components if they are not identical in function and capacity; and
c. substitutions of *refrigerants* having a different designation.

2.3 This standard *shall not* apply to refrigeration systems using ammonia (R-717) as the *refrigerant*.

Informative Note: See ANSI/IIAR 2 [1] for systems using ammonia (R-717).

3. DEFINITIONS

3.1 Defined Terms

administrative control: the use of human action aimed at achieving a safe level of performance from a system or subsystem. Compare to *engineering control*.

approved: acceptable to the authority having jurisdiction (AHJ).

approved, nationally recognized laboratory: a laboratory that is acceptable to the AHJ and provides uniform testing and examination procedures and standards for meeting design, manufacturing, and factory testing requirements of this code; is organized, equipped, and qualified for testing; and has a follow-up inspection service of the current production of the listed products.

back pressure: the static pressure existing at the outlet of an operating *pressure relief device* due to pressure in the discharge line.

balanced relief valve: a *pressure relief valve* that incorporates means of minimizing the effect of *back pressure* on the operational characteristics of the valve (opening pressure, closing pressure, and relieving capacity).

blends: *refrigerants* consisting of mixtures of two or more different chemical compounds, often used individually as *refrigerants* for other applications.

brazed joint: a gas-tight joint obtained by the joining of metal parts with metallic mixtures or alloys that melt at temperatures above 1000°F (537°C) but less than the melting temperatures of the joined parts.

cascade refrigerating system: a refrigerating system having two or more *refrigerant* circuits, each with a *pressure imposing element*, a *condenser*, and an *evaporator*, where the *evaporator* of one circuit absorbs the heat rejected by another (lower-temperature) circuit.

companion* or *block valves: pairs of mating *stop valves* that allow sections of a system to be joined before opening these valves or separated after closing them.

compound refrigerating system: a *multistage refrigerating system* in which a single charge of *refrigerant* circulates through all stages of compression. See *multistage refrigerating system*.

compressor: a machine used to compress *refrigerant* vapor.

compressor unit: a *compressor* with its prime mover and accessories.

condenser: that part of the refrigerating system where *refrigerant* is liquefied by the removal of heat.

condenser coil: a *condenser* constructed of pipe or tubing, not enclosed in a *pressure vessel*.

condensing unit: a combination of one or more power-driven *compressors*, *condensers*, *liquid receivers* (when required), and regularly furnished accessories.

containers, refrigerant: a cylinder for the transportation of *refrigerant*.

corridor: an enclosed passageway that limits travel to a single path.

critical pressure, critical temperature,* and *critical volume: a point on the saturation curve where the *refrigerant* liquid and vapor have identical volume, density, and enthalpy and there is no latent heat.

design pressure: the maximum gage pressure for which a specific part of a refrigerating system is designed.

dual pressure relief device: two *pressure relief devices* mounted on a *three-way valve* that allows one device to remain active while the other is isolated.

duct: a tube or conduit used to convey or encase.

air duct: a tube or conduit used to convey air. (Air passages in *self-contained systems* are not *air ducts*.)

pipe duct: a tube or conduit used to encase pipe or tubing.

engineering control: the use of sensors, actuators, and other equipment to achieve a safe level of performance from a system or subsystem without the aid of human interaction. Compare to *administrative control*.

evaporator: that part of the refrigerating system designed to vaporize liquid *refrigerant* to produce refrigeration.

evaporator coil: an *evaporator* constructed of pipe or tubing, not enclosed in a *pressure vessel*.

flash-gas bypass valve: a device that regulates the removal of gas from the *flash-gas tank* for compression.

flash-gas tank: a tank provided to separate vapor from liquid on the supply side of an *evaporator*. The feed to a *flash-gas tank* is supercritical gas exiting a *gas cooler* that has been throttled to its subcritical region.

fusible plug: a plug containing an alloy that will melt at a *specified* temperature and relieve pressure.

gas cooler: a heat exchanger designed to remove heat from a *transcritical system*.

header: a pipe or tube (extruded, cast, or fabricated) to which other pipes or tubes are connected.

heat exchanger coil: a *refrigerant* containing heat transfer component constructed of pipe or tubing.

heat pump: a refrigerating system used to transfer heat into a space or substance.

highside: a portion or stage of a refrigerating system that is subject to *condenser* or *gas cooler* pressure.

horsepower (hp): the power delivered from the prime mover to the *compressor* of a refrigerating system.

immediately dangerous to life or health (IDLH): the maximum concentration from which unprotected persons are able to escape within 30 minutes without escape-impairing symptoms or irreversible health effects [2].

informative appendix: an appendix that is not part of the standard but is included for information only.

inside dimension: inside diameter, width, height, or cross-sectional diagonal.

intermediate pressure stage: a pressure stage that is sometimes present on carbon dioxide (R-744) *transcritical systems* that operates between the *highside* and *lowside* pressure stages, is regulated by a *flash-gas bypass valve*, and includes *flash-gas tanks* and *gas coolers*, where provided.

internal gross volume: the volume as determined from internal dimensions of the *container* with no allowance for the volume of internal parts.

limited charge system: a system in which, with the *compressor* idle, the *design pressure* will not be exceeded when the *refrigerant* charge has completely evaporated.

liquid receiver: a vessel, permanently connected to a refrigerating system by inlet and outlet pipes, for storage of liquid *refrigerant*.

listed: equipment or materials included in a list published by an *approved*, nationally recognized testing laboratory, inspection agency, or other organization concerned with product evaluation that maintains periodic inspection of production of *listed* equipment or materials and whose listing states either that the equipment or material meets nationally recognized standards or has been tested and found suitable for use in a *specified* manner.

lithium bromide/water absorption system: an absorption system where water (R-718) is the *refrigerant* and lithium bromide (LiBr) is the absorbent.

lobby: a waiting room or large hallway serving as a waiting room.

lower flammability limit (LFL): see definition in ANSI/ASHRAE Standard 34 [2].

low-probability pump: a pump that (a) is permanently sealed to prevent atmospheric release of the pumped fluid, (b) incorporates a static seal to prevent atmospheric release of the pumped fluid, or (c) incorporates not less than two sequential dynamic shaft seals and automatically shuts down upon failure of any seal to prevent atmospheric release of the pumped fluid.

lowside: the portion of a refrigerating system that is subjected to approximate *evaporator* pressure.

machinery: the refrigerating equipment forming a part of the refrigerating system, including, but not limited to, any or all of the following: *compressor*, *condenser*, *liquid receiver*, *evaporator*, and connecting *piping*.

machinery room: a space meeting the requirements of Sections 8.11 and 8.12 that is designed to house *compressors* and *pressure vessels*.

manufacturer: the company or organization that evidences its responsibility by affixing its name, trademark, or trade name to refrigerating equipment.

means of egress: a continuous and unobstructed path of travel from any point in a building or structure to a public way.

mechanical joint: a gas-tight joint obtained by joining metal parts with a positive-holding mechanical construction such as flanged, screwed, or flared joints or compression fittings.

multistage refrigerating system: a refrigerating system in which compression of *refrigerant* is carried out in two or more steps.

nonpositive displacement compressor: a *compressor* in which the increase in vapor pressure is attained without changing the internal volume of the compression chamber.

normative appendix: an appendix including integral parts of the mandatory requirements of the standard, which, for reasons of convenience, are placed after all other normative elements.

occupancy: for class of *occupancy*, see Section 4.

occupational exposure limit (OEL): see definition in ANSI/ASHRAE Standard 34 [2].

occupied space: that portion of the *premises* accessible to or occupied by people, excluding *machinery rooms*.

piping: the pipe or tube used to convey fluid from one part of a refrigeration system to another. *Piping* includes pipe, flanges, bolting, gaskets, valves, fittings, pipe-supporting fixtures, structural attachments, and the pressure containing parts of other components, such as expansion joints, strainers, filters, and devices that serve such purposes as mixing, separating, muffling, snubbing, distributing, metering, or controlling flow.

positive displacement compressor: a *compressor* in which the increase in pressure is attained by changing the internal volume of the compression chamber.

premises: a tract of land and the buildings thereon.

pressure imposing element: any device or portion of the equipment used to increase *refrigerant* pressure.

pressure limiting device: a pressure responsive electronic or mechanical control designed to automatically stop the operation of the pressure limiting element at a predetermined pressure.

pressure relief device: a pressure (not temperature) actuated valve or *rupture member* designed to automatically relieve pressure in excess of its setting.

pressure relief valve: a pressure-actuated valve held closed by a spring or other means and designed to automatically relieve pressure in excess of its setting.

> ***pressure relief valve, pilot-operated:*** a *pressure relief valve* in which the major relieving device is combined with and is controlled by a self-actuated auxiliary *pressure relief valve*.

pressure vessel: any *refrigerant* containing receptacle in a refrigerating system. This does not include *evaporators* where each separate *evaporator* section does not exceed 0.5 ft^3 (0.014 m^3) of *refrigerant* containing volume, regardless of the maximum *inside dimension*. This also does not include *evaporator coils*, *compressors*, *condenser coils*, controls, *headers*, pumps, and *piping*.

pumpdown charge: the quantity of *refrigerant* stored at some point in the refrigeration system for operational, service, or standby purposes.

reclaimed refrigerants: *refrigerants* reprocessed to the same specifications as new *refrigerants* by any means, including distillation. Such *refrigerants* have been chemically analyzed to verify that those specifications have been met.

recovered refrigerants: *refrigerants* removed from a system in any condition without necessarily testing or processing them.

recycled refrigerants: *refrigerants* for which contaminants have been reduced by oil separation, removal of noncondensable gases, and single or multiple passes through filter driers or other devices that reduce moisture, acidity, and particulate matter.

refrigerant: the fluid used for heat transfer in a refrigerating system; the *refrigerant* absorbs heat and transfers it at a higher temperature and a higher pressure, usually with a change of state.

refrigerant concentration limit (RCL): see definition in ANSI/ASHRAE Standard 34 [2].

refrigerant designation: the unique identifying alphanumeric value or *refrigerant* number assigned to an individual *refrigerant* and published in ASHRAE Standard 34 [2].

refrigerant detector: a device that is capable of sensing the presence of *refrigerant* vapor.

refrigerating system: a combination of interconnected parts forming a closed circuit in which *refrigerant* is circulated for the purpose of extracting then rejecting heat. (See Section 5 for classification of *refrigerating systems* by type.)

refrigerating system classification: *refrigerating systems* are classified according to the degree of probability, low or high, that leaked *refrigerant* from a failed connection, seal, or component could enter an occupied area. The distinction is based on the basic design or location of the components. (See Section 5 for classification of *refrigerating systems* by type.)

refrigerating system, direct: see Section 5.1.1.

refrigerating system, indirect: see Section 5.1.2.

rupture member: a device that will rupture and release *refrigerant* to relieve pressure.

saturation pressure: the pressure at which vapor and liquid exist in equilibrium at a given temperature.

secondary coolant: any liquid used for the transmission of heat, without vaporization.

self-contained system: a complete, factory-assembled and factory-tested system that is shipped in one or more sections and has no *refrigerant* containing parts that are joined in the field by other than companion or block valves.

set pressure: the pressure at which a *pressure relief device* or pressure control is set to operate.

shall (shall not): used in this standard when a provision is (or is not) mandatory.

soldered joint: a gas-tight joint formed by joining metal parts with alloys that melt at temperatures not exceeding 800°F (426.5°C) and above 400°F (204.5°C).

specified: explicitly stated in detail. *Specified* limits or prescriptions are mandatory.

stop valve: a device used to shut off the flow of *refrigerant*.

tenant: a person or organization having the legal right to occupy a *premises*.

three-way valve: a service valve for *dual pressure relief devices* that allows using one device while isolating the other from the system, maintaining one valve in operation at all times.

transcritical system: a refrigeration system in which evaporation occurs in the subcritical region and heat rejection can occur at a pressure exceeding the *critical pressure* of the *refrigerant*.

ultimate strength: the stress at which rupture occurs.

unit system: see *self-contained system*.

unprotected tubing: tubing that is unenclosed and therefore exposed to crushing, abrasion, puncture, or similar damage after installation.

zeotropic: refers to *blends* comprising multiple components of different volatility that, when used in refrigeration cycles, change volumetric composition and saturation temperatures as they evaporate (boil) or condense at constant pressure. The word is derived from the Greek words *zein* (to boil) and *tropos* (to change).

3.2 Acronyms, Abbreviations, and Initialisms

AHJ	authority having jurisdiction
IDLH	*immediately dangerous to life or health*
LFL	*lower flammability limit*
OEL	*occupational exposure limit*
RCL	*refrigerant concentration limit*
VAV	variable air volume

4. OCCUPANCY CLASSIFICATION

4.1 Locations of *refrigerating systems* are described by *occupancy* classifications that consider the ability of people to respond to potential exposure to *refrigerant* as follows.

4.1.1 *Institutional occupancy* is a premise or that portion of a premise from which, because they are disabled, debilitated, or confined, occupants cannot readily leave without the assistance of others. Institutional *occupancies* include, among others, hospitals, nursing homes, asylums, and spaces containing locked cells.

4.1.2 *Public assembly occupancy* is a premise or that portion of a premise where large numbers of people congregate and from which occupants cannot quickly vacate the space. Public assembly *occupancies* include, among others, auditoriums, ballrooms, classrooms, passenger depots, restaurants, and theaters.

4.1.3 *Residential occupancy* is a premise or that portion of a premise that provides the occupants with complete independent living facilities, including permanent provisions for living, sleeping, eating, cooking, and sanitation. Residential

occupancies include, among others, dormitories, hotels, multi-unit apartments, and private residences.

4.1.4 *Commercial occupancy* is a premise or that portion of a premise where people transact business, receive personal service, or purchase food and other goods. Commercial *occupancies* include, among others, office and professional buildings, markets (but not large mercantile *occupancies*), and work or storage areas that do not qualify as industrial *occupancies*.

4.1.5 *Large mercantile occupancy* is a premise or that portion of a premise where more than 100 persons congregate on levels above or below street level to purchase personal merchandise.

4.1.6 *Industrial occupancy* is a premise or that portion of a premise that is not open to the public, where access by authorized persons is controlled, and that is used to manufacture, process, or store goods such as chemicals, food, ice, meat, or petroleum.

4.1.7 *Mixed occupancy* occurs when two or more *occupancies* are located within the same building. When each *occupancy* is isolated from the rest of the building by tight walls, floors, and ceilings and by self-closing doors, the requirements for each *occupancy shall* apply to its portion of the building. When the various *occupancies* are not so isolated, the *occupancy* having the most stringent requirements *shall* be the governing *occupancy*.

4.2 Equipment, other than *piping*, located outside a building and within 20 ft (6.1 m) of any building opening *shall* be governed by the *occupancy* classification of the building.

Exception to 4.2: Equipment located within 20 ft (6.1 m) of the building opening for the *machinery room*.

5. REFRIGERATING SYSTEM CLASSIFICATION

5.1 ***Refrigerating Systems.*** *Refrigerating systems* are defined by the method employed for extracting or delivering heat as follows (see Figure 5-1).

5.1.1 A *direct system* is one in which the *evaporator* or *condenser* of the *refrigerating system* is in direct contact with the air or other substances to be cooled or heated.

5.1.2 An *indirect system* is one in which a *secondary coolant* cooled or heated by the *refrigerating system* is circulated to the air or other substance to be cooled or heated. Indirect systems are distinguished by the method of application given below.

5.1.2.1 An *indirect open spray system* is one in which a *secondary coolant* is in direct contact with the air or other substance to be cooled or heated.

5.1.2.2 A *double indirect open spray system* is one in which the secondary substance for an indirect open spray system (Section 5.1.2.1) is heated or cooled by the *secondary coolant* circulated from a second enclosure.

5.1.2.3 An *indirect closed system* is one in which a *secondary coolant* passes through a closed circuit in the air or other substance to be cooled or heated.

5.1.2.4 An *indirect, vented closed system* is one in which a *secondary coolant* passes through a closed circuit in the air or other substance to be cooled or heated, except that the *evaporator* or *condenser* is placed in an open or appropriately vented tank.

5.2 Refrigeration System Classification. For the purpose of applying the data shown in ASHRAE Standard 34 [2], Table 4-1 or 4-2, a *refrigerating system shall* be classified according to the degree of probability that a leakage of *refrigerant* will enter an *occupancy*-classified area as follows.

5.2.1 High-Probability System. A *high-probability system* is any system in which the basic design, or the location of components, is such that a leakage of *refrigerant* from a failed connection, seal, or component will enter the *occupied space*. Typical high-probability systems are (a) direct systems or (b) indirect open spray systems in which the *refrigerant* is capable of producing pressure greater than the *secondary coolant*.

5.2.2 Low-Probability System. A *low-probability system* is any system in which the basic design, or the location of components, is such that leakage of *refrigerant* from a failed connection, seal, or component cannot enter the *occupied space*. Typical low-probability systems are (a) indirect closed systems or (b) double indirect systems and (c) indirect open spray systems if the following condition is met: In a low-probability indirect open spray system, the *secondary coolant* pressure *shall* remain greater than *refrigerant* pressure in all conditions of operation and standby. Operation conditions are defined in Section 9.2.1, and standby conditions are defined in Section 9.2.1.2.

5.3 Changing *Refrigerant*. Changes of *refrigerant* in an existing system to a *refrigerant* with a different *refrigerant designation shall* only be allowed where in accordance with Sections 5.3.1 through 5.3.4.

5.3.1 The change of *refrigerant shall* be *approved* by the owner.

5.3.2 The change of *refrigerant shall* be in accordance with one of the following:

a. Written instructions of the original equipment *manufacturer*
b. An evaluation of the system by a registered design professional or by an *approved* nationally recognized testing laboratory that validates safety and suitability of the replacement *refrigerant*
c. Approval of the AHJ

5.3.3 Where the replacement *refrigerant* is classified into the same safety group, requirements that were applicable to the existing system *shall* continue to apply.

5.3.4 Where the replacement *refrigerant* is classified into a different safety group, the system *shall* comply with the requirements of this standard for a new installation, and the change of *refrigerant shall* require AHJ approval.

6. REFRIGERANT SAFETY CLASSIFICATION

6.1 Single-Compound *Refrigerants*. Single-compound *refrigerants shall* be classified into safety groups in accordance with ASHRAE Standard 34 [2]. The classifications

Paragraph	Designation	Cooling or Heating Source	Air or Substance to be Cooled or Heated
5.1.1	Direct system		
5.1.2.1	Indirect open spray system		
5.1.2.2	Double indirect open spray system		
5.1.2.3	Indirect closed system		
5.1.2.4	Indirect vented closed system		

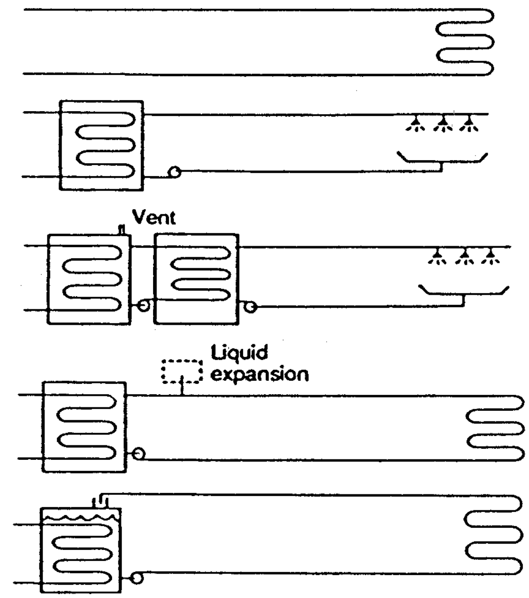


Figure 5-1 ***Refrigerating system*** **designation.**

indicated in the referenced edition of ASHRAE Standard 34 *shall* be used for *refrigerants* that have them assigned. Other *refrigerants shall* be classified in accordance with the criteria in ASHRAE Standard 34; such classifications *shall* be submitted for approval to the AHJ.

6.2 ***Blends.*** *Refrigerant blends shall* be classified following the worst case of fractionation composition, determined in accordance with ASHRAE Standard 34 [2]. For *blends* assigned only a single safety group in ASHRAE Standard 34, that classification *shall* be used.

7. RESTRICTIONS ON REFRIGERANT USE

7.1 General. The *occupancy*, *refrigerating system*, and *refrigerant* safety classifications cited in this section *shall* be determined in accordance with Sections 4, 5, and 6, respectively.

7.2 ***Refrigerant Concentration Limits.*** The concentration of *refrigerant* in a complete discharge of each independent circuit of high-probability systems *shall not* exceed the amounts shown in ASHRAE Standard 34 [2], Table 4-1 or 4-2, except as provided in Sections 7.2.1 and 7.2.2 of this standard. The volume of *occupied space shall* be determined in accordance with Section 7.3.

Exceptions to 7.2:

1. *Listed* equipment containing not more than 6.6 lb (3 kg) of *refrigerant*, regardless of its *refrigerant* safety classification, is exempt from Section 7.2, provided the equipment is installed in accordance with the listing and with the *manufacturer*'s installation instructions.
2. *Listed* equipment for use in laboratories with more than 100 ft^2 (9.3 m^2) of space per person, regardless of the *refrigerant* safety classification, is exempt from Section 7.2, provided that the equipment is installed in accordance with the listing and the *manufacturer*'s installation instructions.

7.2.1 Institutional ***Occupancies.*** The amounts shown in ASHRAE Standard 34 [2], Table 4-1 or 4-2, *shall* be reduced by 50% for all areas of institutional *occupancies*. Also, the total of all Group A2, A3, B2, and B3 *refrigerants shall not* exceed 550 lb (250 kg) in the occupied areas and *machinery rooms* of institutional *occupancies*.

7.2.2 Industrial ***Occupancies*** **and Refrigerated Rooms.** Section 7.2 does not apply in industrial *occupancies* and refrigerated rooms where the following seven conditions are met:

a. Spaces containing the *machinery* are separated from other *occupancies* by tight construction with tight-fitting doors.
b. Access is restricted to authorized personnel.
c. *Refrigerant detectors* are installed with the sensing location and alarm level as required in refrigerating *machinery rooms* in accordance with Section 8.11.5.
d. Open flames and surfaces exceeding 800°F (426.7°C) are not permitted where any Group A2, A3, B2, or B3 *refrigerant* is used.

Table 7-1 Special Quantity Limits for Sealed Ammonia/Water Absorption and *Self-Contained Systems*

Type of Refrigeration System	Maximum lb (kg) for Various *Occupancies*			
	Institutional	Public/Large Mercantile	Residential	Commercial
Sealed Ammonia/*Water Absorption System*				
In public hallways or *lobbies*	0 (0)	0 (0)	3.3 (1.5)	3.3 (1.5)
In adjacent outdoor locations	0 (0)	0 (0)	22 (10)	22 (10)
In other than public hallways or *lobbies*	0 (0)	6.6 (3)	6.6 (3)	22 (10)
Unit Systems				
In other than public hallways or *lobbies*	0 (0)	0 (0)	6.6 (3)	22 (10)

e. All electrical equipment conforms to Class 1, Division 2, of NFPA 70 [3] where the quantity of any Group A2, A3, B2, or B3 *refrigerant* in an independent circuit would exceed 25% of the *LFL* upon release to the space based on the volume determined by Section 7.3.

f. All *refrigerant* containing parts in systems exceeding 100 *hp* (74.6 kW) *compressor* drive power, except *evaporators* used for refrigeration or dehumidification, *condensers* used for heating, control and *pressure relief valves* for either, *low-probability pumps*, and connecting *piping*, are located either in a *machinery room* or outdoors.

7.3 Volume Calculations. The volume used to convert from *refrigerant concentration limits* to *refrigerating system* quantity limits for *refrigerants* in Section 7.2 *shall* be based on the volume of space to which *refrigerant* disperses in the event of a *refrigerant* leak.

7.3.1 Nonconnecting Spaces. Where a *refrigerating system*, or a part thereof, is located in one or more enclosed *occupied spaces* that do not connect through permanent openings or HVAC *ducts*, the volume of the smallest *occupied space shall* be used to determine the *refrigerant* quantity limit in the system. Where different stories and floor levels connect through an open atrium or mezzanine arrangement, the volume to be used in calculating the *refrigerant* quantity limit *shall* be determined by multiplying the floor area of the lowest space by 8.2 ft (2.5 m).

7.3.2 Ventilated Spaces. Where a *refrigerating system*, or a part thereof, is located within an air handler, in an air distribution *duct* system, or in an *occupied space* served by a mechanical ventilation system, the entire air distribution system *shall* be analyzed to determine the worst-case distribution of leaked *refrigerant*. The worst case or the smallest volume in which the leaked *refrigerant* disperses *shall* be used to determine the *refrigerant* quantity limit in the system, subject to the following criteria.

7.3.2.1 Closures. Closures in the air distribution system *shall* be considered. If one or more spaces of several arranged in parallel can be closed off from the source of the *refrigerant* leak, their volumes *shall not* be used in the calculation.

Exceptions to 7.3.2.1: The following closure devices are not considered:

1. Smoke dampers, fire dampers, and combination smoke/fire dampers that close only in an emergency not associated with a *refrigerant* leak.
2. Dampers, such as variable-air-volume (VAV) boxes, that provide limited closure where airflow is not reduced below 10% of its maximum (with the fan running).

7.3.2.2 Plenums. The space above a suspended ceiling *shall not* be included in calculating the *refrigerating system* quantity limits unless such space is part of the air supply or return system.

7.3.2.3 Supply and Return *Ducts*. The volume of the supply and return *ducts* and plenums *shall* be included when calculating the *refrigerating system* quantity limits.

7.4 Location in a *Machinery Room* or Outdoors. All components containing *refrigerant shall* be located either in a *machinery room* or outdoors, where the quantity of *refrigerant* needed exceeds the limits defined by Sections 7.2 and 7.3 or where direct-fired absorption equipment is used.

Exceptions to 7.4:

1. *Self-contained systems* are permitted outside of a *machinery room*, provided that such systems are not located in public hallways or *lobbies* and are limited to the following *occupancies* and *refrigerant* quantities:
   a. 6.6 pounds (3 kg) of *refrigerant* where located in residential *occupancies* or
   b. 22 pounds (10 kg) of *refrigerant* where located in commercial *occupancies*.
2. Sealed absorption systems not exceeding the *refrigerant* quantity limits indicated in Table 7-1.

7.4.1 Direct-fired absorption equipment *shall* be located in a *machinery room* or outdoors.

7.4.2 Nonflammable *Refrigerants*. *Machinery rooms* required by Section 7.4 *shall* be constructed and maintained in accordance with Section 8.11 for Group A1 and B1 *refrigerants*.

7.4.3 Flammable *Refrigerants*. *Machinery rooms* required by Section 7.4 based on flammability *shall* be constructed and maintained in accordance with Sections 8.11 and 8.12 for Group A2, A3, B2, and B3 *refrigerants*. *Machinery rooms* required by Section 7.4 based on flammability *shall* be constructed and maintained in accordance with Sections 8.11.1

through 8.11.5 and Section 8.13 for Group A2L and B2L *refrigerants* other than R-717 (ammonia).

7.5 Additional Restrictions

7.5.1 All *Occupancies*. Sections 7.5.1.1 through 7.5.1.8 apply to all *occupancies*.

7.5.1.1 Flammable *Refrigerants*. The total of all Group A2, A3, B2, and B3 *refrigerants shall not* exceed 1100 lb (500 kg) without approval by the AHJ.

7.5.1.2 *Corridors* and *Lobbies*. *Refrigerating systems* installed in a public *corridor* or *lobby shall* be limited to *unit systems* containing not more than the quantities of Group A1 or B1 *refrigerant* indicated in ASHRAE Standard 34 [2], Table 4-1 or 4-2.

7.5.1.3 *Refrigerant* Type and Purity. *Refrigerants shall* be of a type *specified* by the equipment *manufacturer* unless converted in accordance with Section 7.5.1.8. *Refrigerants* used in new equipment *shall* conform to AHRI 700 [4] in purity unless otherwise *specified* by the equipment *manufacturer*.

7.5.1.4 *Recovered Refrigerants*. *Recovered refrigerants shall not* be reused except in the system from which they were removed, or as provided in Sections 7.5.1.5 or 7.5.1.6. When contamination is evident by discoloration, odor, acid test results, or system history, *recovered refrigerants shall* be reclaimed in accordance with Section 7.5.1.6 before reuse.

7.5.1.5 *Recycled Refrigerants*. *Recycled refrigerants shall not* be reused except in systems using the same *refrigerant* and lubricant designation and belonging to the same owner as the systems from which they were removed. When contamination is evident by discoloration, odor, acid test results, or system history, *recycled refrigerants shall* be reclaimed in accordance with Section 7.5.1.6.

Exception to 7.5.1.5: Drying is not required in order to use *recycled refrigerants* where water is the *refrigerant*, is used as an absorbent, or is a deliberate additive.

7.5.1.6 *Reclaimed Refrigerants*. Used *refrigerants shall not* be reused in a different owner's equipment unless tested and found to meet the requirements of AHRI 700 [4]. Contaminated *refrigerants shall not* be used unless reclaimed and found to meet the requirements of AHRI 700.

7.5.1.7 Mixing of *Refrigerants*. *Refrigerants* with different *refrigerant designations shall* only be mixed in a system in accordance with both of the following:

a. The addition of a second *refrigerant* is allowed by the equipment *manufacturer* and is in accordance with the *manufacturer*'s written instructions.
b. The resulting mixture does not change the *refrigerant* safety group.

7.5.1.8 *Refrigerant* or Lubricant Conversion. The type of *refrigerant* or lubricant in a system *shall not* be changed without evaluation for suitability, notification to the AHJ and the user, due observance of safety requirements, and replacement or addition of signs and identification as required in Section 11.2.3.

7.5.2 Applications for Human Comfort. Group A2, A3, B1, B2L, B2, and B3 *refrigerants shall not* be used in high-probability systems for human comfort. Use of Group A2L *refrigerants shall* be in accordance with Section 7.6.

Exceptions to 7.5.2:

1. These restrictions do not apply to *unit systems* having *refrigerant* quantities less than
   a. 6.6 pounds (3 kg) of *refrigerant* where located in residential *occupancies* or
   b. 22 pounds (10 kg) of *refrigerant* where located in commercial *occupancies*.
2. These restrictions do not apply to industrial *occupancies*.

7.5.3 Higher-Flammability *Refrigerants*. Group A3 and B3 *refrigerants shall not* be used except where *approved* by the AHJ.

Exceptions to 7.5.3:

1. This restriction does not apply to laboratories with more than 100 ft^2 (9.3 m^2) of space per person.
2. This restriction does not apply to industrial *occupancies*.
3. This restriction does not apply to *listed self-contained systems* containing no more than 0.331 lb (150 g) of Group A3 *refrigerant*, provided that the equipment is installed in accordance with the listing and the *manufacturer*'s installation instructions.

7.6 Group A2L *Refrigerants* for Human Comfort. High-probability systems using Group A2L *refrigerants* for human comfort applications *shall* comply with this section.

7.6.1 *Refrigerant Concentration Limits*

7.6.1.1 *Occupied spaces shall* comply with Section 7.2.

7.6.1.2 Unoccupied spaces with *refrigerant* containing equipment, including but not limited to *piping* or tubing, *shall* comply with Section 7.2 except as permitted by Section 7.6.4.

7.6.2 Listing and Installation Requirements. Refrigeration systems *shall* be *listed* and *shall* be installed in accordance with listing, the *manufacturer*'s instructions, and any markings on the equipment restricting the installation.

7.6.2.1 The nameplate required by Section 9.15 *shall* include a symbol indicating that a flammable *refrigerant* is used, as *specified* by the product listing.

7.6.2.2 A label indicating a flammable *refrigerant* is used *shall* be placed adjacent to service ports and other locations where service involving components containing *refrigerant* is performed, as *specified* by the product listing.

7.6.2.3 A *refrigerant detector shall* be provided in accordance with Section 7.6.5 where any of the following apply:

a. For commercial, public assembly, and large mercantile *occupancies*, when the *refrigerant* charge of any independent circuit exceeds 0.212 × *LFL* (lb), where *LFL* is in pounds per 1000 ft^3 (6 × *LFL* [kg] where *LFL* is in kg/m^3), unless the concentration of *refrigerant* in a complete discharge from any independent circuit will not exceed 50% of the *RCL*
b. For residential *occupancies*, when the *refrigerant* charge of any independent circuit exceeds 0.212 × *LFL* (lb),

where *LFL* is in pounds per 1000 ft^3 (6 × *LFL* [kg] where *LFL* is in kg/m^3)

c. When the *occupancy* classification is institutional
d. When required by the product listing
e. When using the provisions of Section 7.6.4

7.6.2.4 When the *refrigerant detector* senses a rise in *refrigerant* concentration above the value *specified* in Section 7.6.5(b), the following actions *shall* be taken:

a. The minimum airflow rate of the supply air fan *shall* be in accordance with the following equation:

$$Q_{min} = 1000 \times M/LFL \qquad \text{(I-P)}$$

$$Q_{min} = 60{,}000 \times M/LFL \qquad \text{(SI)}$$

where

Q_{min} = minimum airflow rate, ft^3/min (m^3/h)

M = *refrigerant* charge of the largest independent refrigerating circuit of the system, lb (kg)

LFL = *lower flammability limit*, lb per 1000 ft^3 (g/m^3)

b. Turn off the *compressor* and all other electrical devices, excluding the control power transformers, control systems, and the supply air fan. The supply air fan *shall* continue to operate for at least five minutes after the *refrigerant detector* has sensed a drop in the *refrigerant* concentration below the value *specified* in Section 7.6.5(b).
c. Any device that controls airflow located within the product or in ductwork that supplies air to the *occupied space shall* be fully open. Any device that controls airflow *shall* be *listed*.
d. Turn off any heaters and electrical devices located in the ductwork. The heaters and electrical devices *shall* remain off for at least five minutes after the *refrigerant detector* has sensed a drop in the *refrigerant* concentration below the value *specified* in Section 7.6.5(b).

7.6.3 Ignition Sources Located in Ductwork

7.6.3.1 Open-flame-producing devices *shall not* be permanently installed in the ductwork that serves the space.

7.6.3.2 Unclassified electrical devices *shall not* be located within the ductwork that serves the space.

7.6.3.3 Devices containing hot surfaces exceeding 1290°F (700°C) *shall not* be located in the ductwork that serves the space unless there is a minimum airflow of 200 ft/min (1.0 m/s) across the heating device(s) and there is proof of airflow before the heating device(s) is energized.

7.6.4 *Compressors* and *Pressure Vessel* Located Indoors. For refrigeration *compressors* and *pressure vessels* located in an indoor space that is accessible only during service and maintenance, it *shall* be permissible to exceed the *RCL* if all of the following provisions are met:

a. The *refrigerant* charge of largest independent refrigerating circuit *shall not* exceed
   1. 6.6 lb (3 kg) for residential and institutional *occupancies* and
   2. 22 lb (10 kg) for commercial and public/large mercantile *occupancies*.
b. The space where the equipment is located *shall* be provided with a mechanical ventilation system in accordance with Section 7.6.4(c) and a *refrigerant detector* in accordance with Section 7.6.5. The mechanical ventilation system *shall* be started when the *refrigerant detector* senses *refrigerant* in accordance with Section 7.6.5. The mechanical ventilation system *shall* continue to operate for at least five minutes after the *refrigerant detector* has sensed a drop in the *refrigerant* concentration below the value *specified* in Section 7.6.5(b).
c. A mechanical ventilation system *shall* be provided that will mix air with leaked *refrigerant* and remove it from the space where the equipment is located. The space *shall* be provided with an exhaust fan. The exhaust fan *shall* remove air from the space where the equipment is located in accordance with the following equation:

$$Q_{min} = 1000 \times M/LFL \qquad \text{(I-P)}$$

$$Q_{min} = 60{,}000 \times M/LFL \qquad \text{(SI)}$$

where

Q_{min} = minimum airflow rate, ft^3/min (m^3/h)

M = *refrigerant* charge of the largest independent refrigerating circuit of the system, lb (kg)

LFL = *lower flammability limit* in lb per 1000 ft^3 (g/m^3)

d. The exhaust air inlet *shall* be located where *refrigerant* from a leak is expected to accumulate. The bottom of the air inlet elevation *shall* be within 12 in. (30 cm) of the lowest elevation in the space where the *compressor* or *pressure vessel* is located. Provision *shall* be made for makeup air to replace that being exhausted. Openings for the makeup air *shall* be positioned such that air will mix with leaked *refrigerant*.
e. Air that is exhausted from the ventilation system *shall* be either
   1. discharged outside of the building envelope or
   2. discharged to an indoor space, provided that the *refrigerant* concentration will not exceed the limit *specified* in Section 7.6.1.
f. In addition to the requirements of Section 7.6.3, there *shall* be no open-flame-producing devices that do not contain a flame arrestor, or hot surfaces exceeding 1290°F (700°C) that are installed within space where the equipment is located.

7.6.5 *Refrigerant Detectors.* *Refrigerant detectors* required by Section 7.6.2 *shall* meet the following requirements:

a. *Refrigerant detectors* that are part of the listing *shall* be evaluated by the testing laboratory as part of the equipment listing.
b. *Refrigerant detectors*, as installed, *shall* activate the functions required by Section 7.6.2.4 within a time not to exceed 15 seconds when the *refrigerant* concentration reaches 25% of the *LFL*.
c. *Refrigerant detectors shall* be located such that *refrigerant* will be detected if the *refrigerating system* is operating

or not operating. Use of more than one *refrigerant detector shall* be permitted.

1. For *refrigerating systems* that are connected to the *occupied space* through ductwork, *refrigerant detectors shall* be located within the *listed* equipment.
2. For *refrigerating systems* that are directly connected to the *occupied space* without ductwork, the *refrigerant detector shall* be located in the equipment, or *shall* be located in the *occupied space* at a height of not more than 12 in. (30 cm) above the floor and within a horizontal distance of not more 3.3 ft (1.0 m) with a direct line of sight of the unit.

d. *Refrigerant detectors shall* provide a means for an automatic operational self-test as provided in the product listing. Use of a *refrigerant* test gas is not required. If a failure is detected, a trouble alarm *shall* be activated, and the actions required by Section 7.6.2.4 *shall* be initiated.

e. *Refrigerant detectors shall* be tested during installation to verify the set point and response time as required by Section 7.6.5(b). After installation, the *refrigerant detector shall* be tested to verify the set point and response time annually or at an interval not exceeding the *manufacturer*'s installation instructions, whichever is less.

8. INSTALLATION RESTRICTIONS

8.1 Foundations. Foundations and supports for *condensing units* or *compressor units shall* be of noncombustible construction and capable of supporting loads imposed by such units. Isolation materials, such as rubber, are permissible between the foundation and condensing or *compressor units*.

8.2 Guards. Moving *machinery shall* be guarded in accordance with *approved* safety standards [5].

8.3 Safe Access. A clear and unobstructed approach and space *shall* be provided for inspection, service, and emergency shutdown of *condensing units*, *compressor units*, *condensers*, *stop valves*, and other serviceable components of refrigerating *machinery*. Permanent ladders, platforms, or portable access equipment *shall* be provided in accordance with the requirements of the AHJ.

8.4 Water Connections. Water supply and discharge connections *shall* be made in accordance with the requirements of the AHJ.

8.5 Electrical Safety. Electrical equipment and wiring *shall* be installed in accordance with the *National Electrical Code* [3] and the requirements of the AHJ.

8.6 Gas Fuel Equipment. Gas fuel devices and equipment used with *refrigerating systems shall* be installed in accordance with *approved* safety standards and the requirements of the AHJ.

8.7 *Air Duct* Installation. *Air duct* systems of air-conditioning equipment for human comfort using mechanical refrigeration *shall* be installed in accordance with *approved* safety standards, the requirements of the AHJ, and the requirements of Section 8.11.7.

8.8 *Refrigerant* Parts in *Air Duct*. Joints and all *refrigerant* containing parts of a *refrigerating system* located in an *air duct* carrying conditioned air to and from an *occupied space shall* be constructed to withstand a temperature of 700°F (371°C) without leakage into the airstream.

8.9 *Refrigerant* Pipe Joint Inspection. *Refrigerant* pipe joints erected on the *premises shall* be exposed to view for visual inspection prior to being covered or enclosed.

8.10 Location of *Refrigerant Piping*

8.10.1 *Refrigerant piping* crossing an open space that affords passageway in any building *shall not* be less than 7.25 ft (2.2 m) above the floor, unless the *piping* is located against the ceiling of such space and is permitted by the AHJ.

8.10.2 Passages *shall not* be obstructed by *refrigerant piping*. *Refrigerant piping shall not* be placed in any elevator, dumbwaiter, or other shaft containing a moving object or in any shaft that has openings to living quarters or to *means of egress*. *Refrigerant piping shall not* be installed in an enclosed public stairway, stair landing, or *means of egress*.

8.10.3 *Refrigerant piping shall not* penetrate floors, ceilings, or roofs.

Exceptions to 8.10.3:

1. Penetrations connecting the basement and the first floor.
2. Penetrations connecting the top floor and a *machinery* penthouse or roof installation.
3. Penetrations connecting adjacent floors served by the refrigeration system.
4. Penetrations of a direct system where the *refrigerant* concentration does not exceed that *listed* in ASHRAE Standard 34 [2], Table 4-1 or Table 4-2, for the smallest *occupied space* through which the *refrigerant piping* passes.
5. In other than industrial *occupancies* and where the *refrigerant* concentration exceeds that *listed* in ASHRAE Standard 34, Table 4-1 or 4-2, for the smallest *occupied space*, penetrations that connect separate pieces of equipment that are
   a. enclosed by an *approved* gas-tight, fire-resistive *duct* or shaft with openings to those floors served by the *refrigerating system* or
   b. located on the exterior wall of a building when vented to the outdoors or to the space served by the system and not used as an air shaft, closed court, or similar space.

8.10.4 *Refrigerant piping* installed in concrete floors *shall* be encased in *pipe duct*. *Refrigerant piping shall* be properly isolated and supported to prevent damaging vibration, stress, or corrosion.

8.11 Refrigerating *Machinery Room*, General Requirements. When a *refrigerating system* is located indoors and a *machinery room* is required by Section 7.4, the *machinery room shall* be in accordance with the following provisions.

8.11.1 *Machinery rooms* are not prohibited from housing other mechanical equipment unless specifically prohibited elsewhere in this standard. A *machinery room shall* be so dimensioned that parts are accessible with space for service, maintenance, and operations. There *shall* be clear head room

of not less than 7.25 ft (2.2 m) below equipment situated over passageways.

8.11.2 Each refrigerating *machinery room shall* have a tight-fitting door or doors opening outward, self-closing if they open into the building and adequate in number to ensure freedom for persons to escape in an emergency. With the exception of access doors and panels in *air ducts* and air-handling units conforming to Section 8.11.3, there *shall* be no openings that will permit passage of escaping *refrigerant* to other parts of the building.

8.11.3 There *shall* be no airflow to or from an *occupied space* through a *machinery room* unless the air is ducted and sealed in such a manner as to prevent any *refrigerant* leakage from entering the airstream. Access doors and panels in ductwork and air-handling units *shall* be gasketed and tight fitting.

8.11.4 Access. Access to the refrigerating *machinery room shall* be restricted to authorized personnel. Doors *shall* be clearly marked, or permanent signs *shall* be posted at each entrance to indicate this restriction.

8.11.5 Each refrigerating *machinery room shall* contain a detector, located in an area where *refrigerant* from a leak will concentrate, that actuates an alarm and mechanical ventilation in accordance with Section 8.11.7 at a set point not greater than the *OEL* value as published in ASHRAE Standard 34 [2]. For *refrigerants* that do not have a published *OEL* value in Standard 34, a set point determined in accordance with the *OEL* as defined by Standard 34 *shall* be *approved* by the AHJ. The alarm *shall* annunciate visual and audible alarms inside the refrigerating *machinery room* and outside each entrance to the refrigerating *machinery room*. The alarms required in this section *shall* be of the manual reset type with the reset located inside the refrigerating *machinery room*. Alarms set at other levels (such as *IDLH*) and automatic reset alarms are permitted in addition to those required by this section. The meaning of each alarm *shall* be clearly marked by signage near the annunciators.

Exceptions to 8.11.5:

1. Detectors are not required when only systems using R-718 (water) are located in the refrigerating *machinery room*.
2. For Group A2L and B2L other than ammonia, refer to Section 8.13.

8.11.6 *Machinery rooms shall* be vented to the outdoors, using mechanical ventilation in accordance with Sections 8.11.7 and 8.11.8.

8.11.7 Mechanical ventilation referred to in Section 8.11.6 *shall* be by one or more power-driven fans capable of exhausting air from the *machinery room* at least in the amount given in the formula in Section 8.11.8. To obtain a reduced airflow for normal ventilation, multiple fans or multispeed fans *shall* be used. Provision *shall* be made for inlet air to replace that being exhausted. Openings for inlet air *shall* be positioned to avoid recirculation. Air supply and exhaust *ducts* to the *machinery room shall* serve no other area. The discharge of the air *shall* be to the outdoors in such a manner as not to cause a nuisance or danger. The mechanical exhaust inlets *shall* be located in an area where *refrigerant* from a leak is likely to concentrate, in consideration of the location of the replacement air paths, refrigerating machines, and the density of the *refrigerant* relative to air.

8.11.8 Ventilation Airflow. For Group A1, A2, A3, B1, B2, and B3 the airflow *shall* comply with Section 8.11.8.1. For Group A2L and B2L other than R-717 (ammonia) the airflow *shall* comply with Section 8.13.

8.11.8.1 The mechanical ventilation required to exhaust an accumulation of *refrigerant* due to leaks or a rupture of the system *shall* be capable of removing air from the *machinery room* in not less than the following quantity:

$$Q = 100 \times G^{0.5} \qquad \text{(I-P)}$$

$$Q = 70 \times G^{0.5} \qquad \text{(SI)}$$

where

Q = airflow, cfm (L/s)

G = mass of *refrigerant* in the largest system, any part of which is located in the *machinery room*, lb (kg)

A part of the refrigerating *machinery room* mechanical ventilation *shall* be

a. operated, when occupied, to supply at least 0.5 cfm/ft^2 (2.54 L/s/m^2) of *machinery room* area or 20 cfm (9.44 L/s) per person and
b. operable when occupied at a volume required to not exceed the higher of a temperature rise of 18°F (10°C) above inlet air temperature or a maximum temperature of 122°F (50°C).

8.11.9 No open flames that use combustion air from the *machinery room shall* be installed where any *refrigerant* is used. Combustion equipment *shall not* be installed in the same *machinery room* with *refrigerant* containing equipment except under one of the following conditions:

a. Combustion air is ducted from outside the *machinery room* and sealed in such a manner as to prevent any *refrigerant* leakage from entering the combustion chamber.
b. A *refrigerant detector*, conforming to Section 8.11.5, is employed to automatically shut down the combustion process in the event of *refrigerant* leakage.

Exception to 8.11.9: *Machinery rooms* where only carbon dioxide (R-744) or water (R-718) is the *refrigerant*.

8.12 *Machinery Room*, Special Requirements. In cases *specified* in the rules of Section 7.4, a refrigerating *machinery room shall* meet the following special requirements in addition to those in Section 8.11:

a. There *shall* be no flame-producing device or continuously operating hot surface over 800°F (427°C) permanently installed in the room.
b. Doors communicating with the building *shall* be *approved*, self-closing, tight-fitting fire doors.
c. Walls, floor, and ceiling *shall* be tight and of noncombustible construction. Walls, floor, and ceiling separating the refrigerating *machinery room* from other *occupied spaces shall* be of at least one-hour fire-resistive construction.

d. Exterior openings, if present, *shall not* be under any fire escape or any open stairway.
e. All pipes piercing the interior walls, ceiling, or floor of such rooms *shall* be tightly sealed to the walls, ceiling, or floor through which they pass.
f. When *refrigerants* of Groups A2, A3, B2, and B3 are used, the *machinery room shall* conform to Class 1, Division 2, of the *National Electrical Code* [3]. When *refrigerant* Groups A1 and B1 are used, the *machinery room* is not required to meet Class 1, Division 2, of the *National Electrical Code*.
g. Remote control of the mechanical equipment in the refrigerating *machinery room shall* be provided immediately outside the *machinery room* door solely for the purpose of shutting down the equipment in an emergency. Ventilation fans *shall* be on a separate electrical circuit and have a control switch located immediately outside the *machinery room* door.

8.13 *Machinery Room*, A2L and B2L Other than R-717 (Ammonia). When required by Section 7.4.2, *machinery rooms shall* comply with Sections 8.13.1 through 8.13.6.

8.13.1 There *shall* be no flame-producing device or hot surface over 1290°F (700°C) in the room, other than that used for maintenance or repair, unless installed in accordance with Section 8.11.9.

8.13.2 Doors communicating with the building *shall* be *approved*, self-closing, tight-fitting fire doors.

8.13.3 Walls, floor, and ceiling *shall* be tight and of noncombustible construction. Walls, floor, and ceiling separating the refrigerating *machinery room* from other *occupied spaces shall* be of at least one-hour fire-resistive construction.

8.13.4 Exterior openings, if present, *shall not* be under any fire escape or any open stairway.

8.13.5 All pipes piercing the interior walls, ceiling, or floor of such rooms *shall* be tightly sealed to the walls, ceiling, or floor through which they pass.

8.13.6 When any *refrigerant* of Groups A2, A3, B2, or B3 are used, the *machinery room shall* be designated as Class I, Division 2 hazardous (classified) electrical location in accordance with the *National Electrical Code* [3]. When the only flammable *refrigerants* used are from Group A2L or B2L other than R-717 (ammonia), the *machinery room shall* comply with both Section 8.13.6.1 for ventilation and Section 8.13.6.2 for *refrigerant* detection, or *shall* be designated as Class I, Division 2 hazardous (classified) electrical location in accordance with the *National Electrical Code* [3].

8.13.6.1 The *machinery room shall* have a mechanical ventilation system in accordance with Section 8.13.11. The mechanical ventilation system *shall*

a. run continuously, and failure of the mechanical ventilation system actuates an alarm, or
b. be activated by one or more *refrigerant detectors*, conforming to requirements of Section 8.13.8.

8.13.6.2 Detection of *refrigerant* concentration that exceeds 25% of the *LFL* or the upper detection limit of the *refrigerant detector*, whichever is lower, *shall* automatically de-energize the following equipment in the *machinery room*:

a. *Refrigerant compressors*
b. *Refrigerant* pumps
c. Normally closed automatic *refrigerant* valves
d. Other unclassified electrical sources of ignition with apparent power rating greater than 1 kVA, where the apparent power is the product of the circuit voltage and current rating

8.13.7 Remote control of the mechanical equipment in the refrigerating *machinery room shall* be provided immediately outside the *machinery room* door solely for the purpose of shutting down the equipment in an emergency. Ventilation fans *shall* be on a separate electrical circuit and have a control switch located immediately outside the *machinery room* door.

8.13.8 Each refrigerating *machinery room* in accordance with Section 8.13 *shall* contain one or more *refrigerant detectors* in accordance with Section 8.13.9, with sensing element located in areas where *refrigerant* from a leak will concentrate, with one or more set points that activate responses in accordance with Section 8.13.10 for alarms and Section 8.13.11 for mechanical ventilation. Multiport-type devices *shall* be prohibited.

8.13.9 *Refrigerant detectors* required by Section 8.13 *shall* meet all of the following conditions:

a. A *refrigerant detector shall* be capable of detecting each of the specific *refrigerant designations* in the *machinery room*.
b. The *refrigerant detector shall* activate responses within a time not to exceed a limit *specified* in Sections 8.13.10 and 8.13.11 after exposure to *refrigerant* concentration exceeding a limit value *specified* in Sections 8.13.10 and 8.13.11.
c. The *refrigerant detector shall* have a set point not greater than the applicable *OEL* value as published in ASHRAE Standard 34 [2]. The applicable *OEL* value *shall* be the lowest *OEL* value for any *refrigerant designation* in the *machinery room*. For *refrigerants* that do not have a published *OEL* value in Standard 34, use a value determined in accordance with the *OEL* as defined by Standard 34 where *approved* by the AHJ.
d. The *refrigerant detector shall* have a set point not greater than the applicable *RCL* value as published in ASHRAE Standard 34 [2]. The applicable *RCL* value *shall* be the lowest *RCL* value for any *refrigerant designation* in the *machinery room*. For *refrigerants* that do not have a published *RCL* value in Standard 34, use a value determined in accordance with the *RCL* as defined by Standard 34 where *approved* by the AHJ.
e. The *refrigerant detector shall* provide a means for automatic self testing and *shall* be in accordance with Section 8.13.10.4. The *refrigerant detector shall* be tested during installation and annually thereafter, or at an interval not exceeding the *manufacturer*'s installation instructions, whichever is less. Testing *shall* verify compliance with the alarm set points and response times per Sections 8.13.10 and 8.13.11.

8.13.10 Alarms required by Section 8.13.8 *shall* comply with the following.

Table 8-1 *Refrigerant Detector* Set Points, Response Times, Alarms, and Ventilation Levels

Limit Value	Response Time, seconds	Alarm Type	Alarm Reset Type	Ventilation Level	Ventilation Reset Type
Set point ≤ *OEL*	≤300	Trouble alarm	Automatic	Level 1	Automatic
Set point ≤ *RCL*	≤15	Emergency alarm	Manual	Level 2	Manual

Table 8-2 Level 1 Ventilation Rate for Class 2L *Refrigerants*

Status	Airflow
Operated when occupied, and operated when activated in accordance with Section 8.13.9(c) and Table 8-1	The greater of a. 0.5 ft^3/min per ft^3 (2.54 L/s per m^3) of *machinery room* area or b. 20 ft^3/min (9.44 L/s) per person
Operable when occupied	With or without mechanical cooling of the *machinery room*, the greater of a. the airflow rate required to not exceed a temperature rise of 18°F (10°C) above inlet air temperature or b. the airflow rate required to not exceed a maximum air temperature of 122°F (50°C) in the *machinery room*

8.13.10.1 The alarm *shall* have visual and audible annunciation inside the refrigerating *machinery room* and outside each entrance to the refrigerating *machinery room*.

8.13.10.2 The *refrigerant detector* set points *shall* activate an alarm in accordance with the type of reset in Table 8-1. Manual reset type alarms *shall* have the reset located inside the refrigerating *machinery room*.

8.13.10.3 Alarms set at levels other than Table 8-1 (such as *IDLH*) and automatic reset alarms are permitted in addition to those required by Section 8.13.10. The meaning of each alarm *shall* be clearly marked by signage near the annunciators.

8.13.10.4 In the event of a failure during a *refrigerant detector* self test in accordance with Section 8.13.9(e), a trouble alarm signal *shall* be transmitted to an *approved* monitored location.

8.13.11 Ventilation. *Machinery rooms*, in accordance with Section 8.13, *shall* be vented to the outdoors, using mechanical ventilation in accordance with Sections 8.13.11.1, 8.13.11.2, and 8.13.11.3.

8.13.11.1 Mechanical ventilation referred to in Section 8.13.11 *shall* be in accordance with all of the following:

a. Include one or more power-driven fans capable of exhausting air from the *machinery room*; multispeed fans *shall* be permitted.
b. Electric motors driving fans *shall not* be placed inside *ducts*; fan rotating elements *shall* be nonferrous or nonsparking, or the casing *shall* consist of or be lined with such material.
c. Include provision to supply makeup air to replace that being exhausted; *ducts* for supply to and exhaust from the *machinery room shall* serve no other area; the makeup air supply locations *shall* be positioned relative to the exhaust air locations to avoid short circuiting.
d. Inlets to the exhaust *ducts shall* be located in an area where *refrigerant* from a leak will concentrate, in consideration of the location of the replacement supply air paths, refrigerating machines, and the density of the *refrigerant* relative to air.
e. Inlets to exhaust *ducts shall* be within 1 ft (0.3 m) of the lowest point of the *machinery room* for *refrigerants* that are heavier than air and *shall* be within 1 ft (0.3 m) of the highest point for *refrigerants* that are lighter than air.
f. The discharge of the exhaust air *shall* be to the outdoors in such a manner as not to cause a nuisance or danger.

8.13.11.2 Level 1 Ventilation. The refrigerating *machinery room* mechanical ventilation in Section 8.13.11.1 *shall* exhaust at an airflow rate not less than shown in Table 8-2.

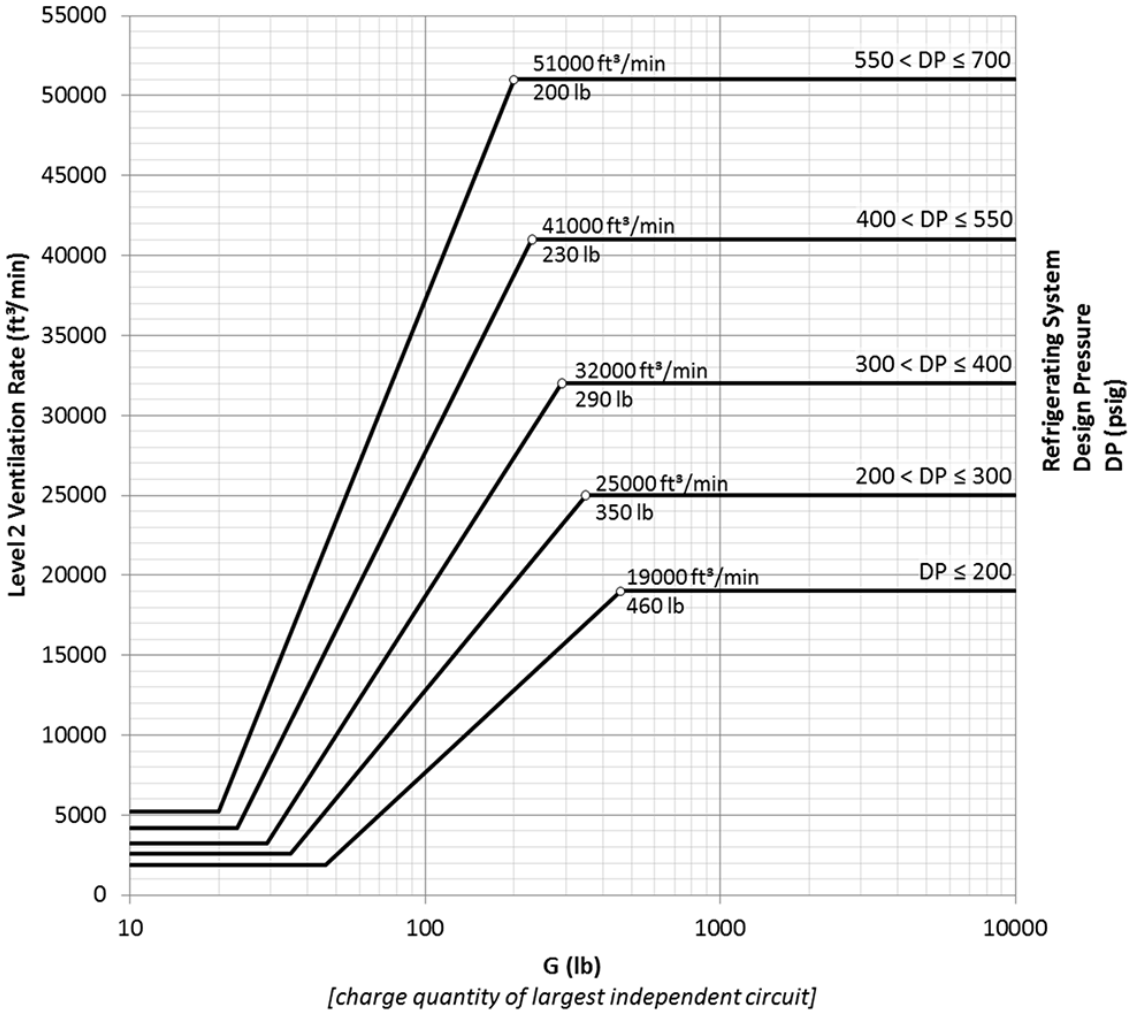
8.13.11.3 Level 2 Ventilation. A part of the refrigerating *machinery room* mechanical ventilation referred to in Section 8.13.11.1 *shall* exhaust an accumulation of *refrigerant* due to leaks or a rupture of a *refrigerating system*, or portion thereof, in the *machinery room*. The *refrigerant detectors* required in accordance with Section 8.13.8 *shall* activate ventilation at a set point and response time in accordance with Table 8-1, at an airflow rate not less than the value determined in accordance with Section 8.13.11.4.

When multiple *refrigerant designations* are in the *machinery room*, evaluate the required airflow according to each *refrigerating system*, and the highest airflow quantity *shall* apply.

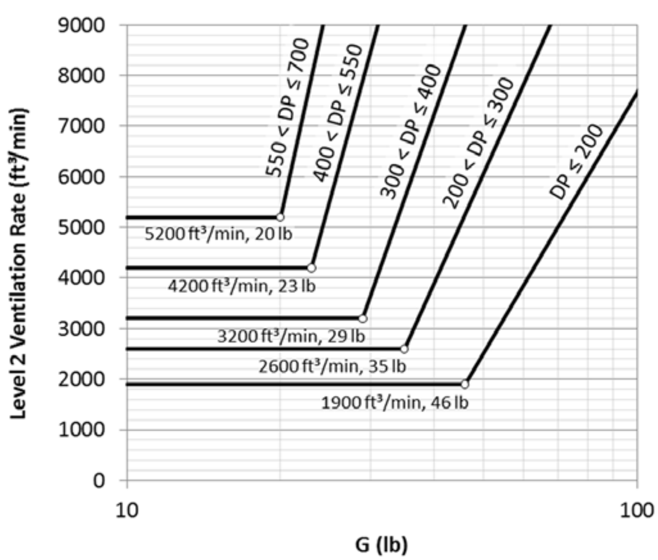
Ventilation reset *shall* be in accordance with the type of reset in Table 8-1. Manual-type ventilation reset *shall* have the reset located inside the refrigerating *machinery room*.

8.13.11.4 Safety Group A2L, B2L Other than Ammonia. When required by Section 8.13.11.3, the total airflow for Level 2 ventilation *shall* be not less than the airflow rate determined by Figure 8-1 (I-P) or Figure 8-2 (SI).

8.14 When a *refrigerating system* is located outdoors more than 20 ft (6.1 m) from building openings and is enclosed by a penthouse, lean-to, or other open structure, natural or mechanical ventilation *shall* be provided. The requirements for such natural ventilation are as follows:

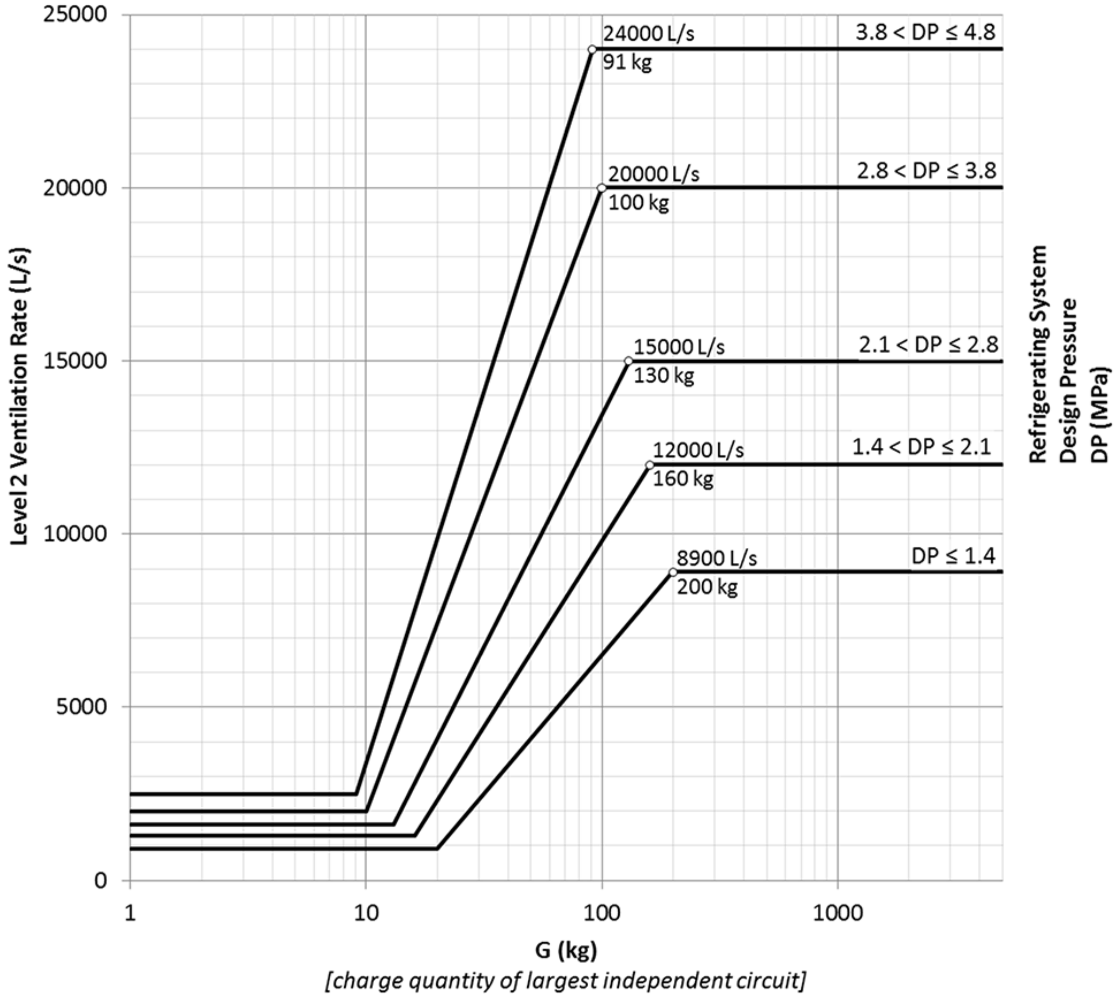


(a)

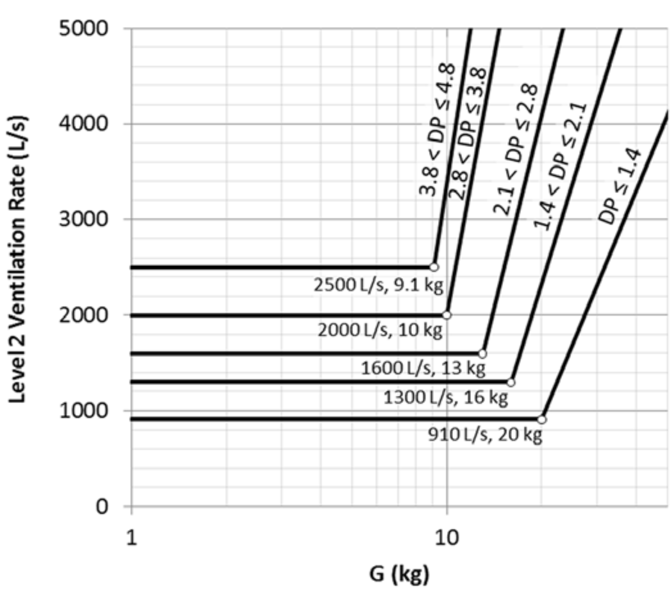


(b)

Figure 8-1 (a) Level 2 ventilation rate for Class 2L *refrigerants* (I-P) with (b) detail.



(a)



(b)

Figure 8-2 (a) Level 2 ventilation rate for Class 2L *refrigerants* (SI) with (b) detail.

a. The free-aperture cross section for the ventilation of a *machinery room shall* be at least

$$F = G^{0.5} \quad \text{(I-P)}$$

$$F = 0.138 \times G^{0.5} \quad \text{(SI)}$$

where

F = the free opening area, ft^2 (m^2)

G = the mass of *refrigerant* in the largest system, any part of which is located in the *machinery room*, lb (kg)

b. Locations of the gravity ventilation openings *shall* be based on the relative density of the *refrigerant* to air.

8.15 Purge Discharge. The discharge from purge systems *shall* be governed by the same rules as *pressure relief devices* and *fusible plugs* (see Section 9.7.8) and *shall* be piped in conjunction with these devices.

Exception to 8.15: When R-718 (water) is the *refrigerant*.

9. DESIGN AND CONSTRUCTION OF EQUIPMENT AND SYSTEMS

9.1 Materials

9.1.1 Materials used in the construction and installation of *refrigerating systems shall* be suitable for conveying the *refrigerant* used. Materials *shall not* be used that will deteriorate because of the *refrigerant*, the lubricant, or their combination in the presence of air or moisture to a degree that poses a safety hazard.

9.1.2 Aluminum, zinc, magnesium, or their alloys *shall not* be used in contact with methyl chloride. Magnesium alloys *shall not* be used in contact with any halogenated *refrigerants*.

9.1.3 *Piping* material used in the discharge line of a *pressure relief device* or *fusible plug shall* be the same as required for *refrigerants*.

Exception to 9.1.3: When discharging to atmosphere, Type F buttweld pipe is allowed.

9.2 System *Design Pressure*

9.2.1 *Design pressures shall not* be less than pressure arising under maximum operating, standby, or shipping conditions. When selecting the *design pressure*, allowance *shall* be provided for setting *pressure limiting devices* and *pressure relief devices* to avoid nuisance shutdowns and loss of *refrigerant*. *ASME Boiler and Pressure Vessel Code*, Section VIII, Division I [6], Appendix M, contains information on the appropriate allowances for *design pressure*.

Refrigerating equipment *shall* be designed for a vacuum of 29.0 in. Hg (32°F). *Design pressure* for *lithium bromide absorption systems shall not* be less than gage pressure 5.00 psi (34.5 kPa). *Design pressure* for mechanical refrigeration systems *shall not* be less than gage pressure 15.0 psi (103 kPa) and, except as noted in Sections 9.2.2, 9.2.3, 9.2.4, 9.2.5, and 9.2.6, *shall not* be less than the *saturation pressure* (gage) corresponding to the following temperatures:

a. *Lowsides* of all systems: 80°F (26.7°C)
b. Highsides of all water-cooled or evaporatively cooled systems: 30°F (16.7°C) higher than the summer 1% wet-bulb temperature for the location, as applicable, or 15°F (8.3°C) higher than the highest design leaving condensing water temperature for which the equipment is designed, or 104°F (40°C), whichever is greatest
c. Highsides of all air-cooled systems: 30°F (16.7°C) higher than the highest summer 1% design dry-bulb temperature for the location but not lower than 122°F (50°C)

Informative Note: See Informative Reference 7 for sources of information relating to summer 1% wet-bulb and summer 1% dry-bulb temperature data for a specific location.

9.2.1.1 The *design pressure* selected *shall* exceed maximum pressures attained under any anticipated normal operating conditions, including conditions created by expected fouling of heat exchange surfaces.

9.2.1.2 Standby conditions are intended to include normal conditions that are capable of being attained when the system is not in operation (e.g., maintenance, shutdown, power failure). Selection of the *design pressure* for *lowside* components *shall* also consider pressure developed in the *lowside* of the system from equalization, or heating due to changes in ambient temperature, after the system has stopped.

9.2.1.3 The *design pressure* for both *lowside* and *highside* components that are shipped as part of a gas- or *refrigerant*-charged system *shall* be selected with consideration of internal pressures arising from exposure to maximum temperatures anticipated during the course of shipment.

9.2.2 The *design pressure* for either the *highside* or *lowside* need not exceed the *critical pressure* of the *refrigerant* unless such pressures are anticipated during operating, standby, or shipping conditions.

9.2.3 When part of a *limited charge system* is protected by a *pressure relief device*, the *design pressure* of the part need not exceed the setting of the *pressure relief device*.

9.2.4 When a *compressor* is used as a booster and discharges into the suction side of another *compressor*, the booster *compressor shall* be considered a part of the *lowside*.

9.2.5 Components connected to *pressure vessels* and subject to the same pressure as the *pressure vessel shall* have a *design pressure* no less than the *pressure vessel*.

9.2.6 Components of *refrigerating systems* that use carbon dioxide (R-744) as a heat transfer fluid *shall* comply with the minimum *design pressure* requirements in Sections 9.2.6.1 through 9.2.6.4. The pressure at maximum operating conditions referenced by Sections 9.2.6.1 through 9.6.2.3 *shall* be the highest pressure experienced during the following conditions:

a. Start-up
b. Full-load operation at the warmest heat-rejection design condition
c. Defrost, for systems designed with defrost capability

9.2.6.1 For circuits without *compressor*, the *design pressure shall* be not less than 120% of the circuit pressure at maximum operating conditions.

9.2.6.2 Cascade *refrigerating systems shall* comply with all of the following:

a. The *highside design pressure shall* be not less than 120% of the maximum pressure developed by a *pressure imposing element*.
b. The *lowside design pressure shall* be not less than 120% of the pressure at maximum operating conditions, corresponding to the warmest location in the circuit.

9.2.6.3 Transcritical *refrigerating systems shall* comply with all of the following:

a. The *highside design pressure shall* be not less than 110% of the maximum pressure developed by a *pressure imposing element*.
b. The *lowside design pressure shall* be not less than 120% of the pressure at maximum operating conditions.
c. The *intermediate pressure stage*, where present, *shall* have a *design pressure* that is not less than 120% of the pressure at maximum operating conditions.

9.2.6.4 Where the *design pressure* calculated in Sections 9.2.6.1 through 9.2.6.3 will be exceeded in the event of *refrigerant* warming to ambient temperature during normal standstill or emergency standstill conditions, one of the following means *shall* be provided to maintain pressure at or below the *design pressure*:

a. A pressure relieving connection that will relieve excess pressure to a lower pressure part of the system.
b. A *pressure relief valve* in accordance with Section 9.7.5.

9.3 *Refrigerant*-Containing *Pressure Vessels*

9.3.1 *Inside Dimensions* 6 in. (152 mm) or Less. These vessels have an inside diameter, width, height, or cross-sectional diagonal not exceeding 6 in. (152 mm), with no limitation on length of vessel.

9.3.1.1 *Pressure vessels* having *inside dimensions* of 6 in. (152 mm) or less *shall* be

a. *listed* either individually or as part of an assembly by an *approved*, nationally recognized testing laboratory;
b. marked directly on the vessel or on a nameplate attached to the vessel with a "U" or "UM" symbol signifying compliance with *ASME Boiler and Pressure Vessel Code*, Section VIII [6]; or
c. when requested by the AHJ, the *manufacturer shall* provide documentation to confirm that the vessel meets the design, fabrication, and testing requirements of *ASME Boiler and Pressure Vessel Code*, Section VIII.

Exception to 9.3.1.1: Vessels having an internal or external *design pressure* of 15 psig (103.4 kPa gage) or less.

Pressure vessels having *inside dimensions* of 6 in. (152 mm) or less *shall* be protected by either a *pressure relief device* or a *fusible plug*.

9.3.1.2 If a *pressure relief device* is used to protect a *pressure vessel* having an *inside dimension* of 6 in. (152 mm) or less, the *ultimate strength* of the *pressure vessel* so protected *shall* be sufficient to withstand a pressure at least 3.0 times the *design pressure*.

9.3.1.3 If a *fusible plug* is used to protect a *pressure vessel* having an inside diameter of 6 in. (152 mm) or less, the *ultimate strength* of the *pressure vessel* so protected *shall* be sufficient to withstand a pressure 2.5 times the *saturation pressure* of the *refrigerant* used at the temperature stamped on the *fusible plug*, or 2.5 times the *critical pressure* of the *refrigerant* used, whichever is less.

9.3.2 *Inside Dimensions* Greater than 6 in. (152 mm). *Pressure vessels* having an inside diameter exceeding 6 in. (152 mm) and having an internal or external *design pressure* greater than 15 psig (103.4 kPa gage) *shall* be directly marked, or marked on a nameplate, with a "U" or "UM" symbol signifying compliance with the rules of *ASME Boiler and Pressure Vessel Code*, Section VIII [6].

9.3.3 *Pressure Vessels* for 15 psig (103.4 kPa gage) or Less. *Pressure vessels* having an internal or external *design pressure* of 15 psig (103.4 kPa gage) or less *shall* have an *ultimate strength* to withstand at least 3.0 times the *design pressure* and *shall* be tested with a pneumatic test pressure no less than 1.25 times the *design pressure* or a hydrostatic test pressure no less than 1.50 times the *design pressure*.

9.4 Pressure Relief Protection

9.4.1 *Refrigerating systems shall* be protected by a *pressure relief device* or other *approved* means to safely relieve pressure due to fire or other abnormal conditions.

9.4.2 *Pressure vessels shall* be protected in accordance with Section 9.7. *Pressure relief devices* are acceptable if they either bear a nameplate or are directly marked with a "UV" or "VR" symbol signifying compliance with *ASME Boiler and Pressure Vessel Code*, Section VIII [6].

9.4.3 Hydrostatic Expansion. Pressure rise resulting from hydrostatic expansion due to temperature rise of liquid *refrigerant* trapped in or between closed valves *shall* be addressed by the following.

9.4.3.1 If trapping of liquid with subsequent hydrostatic expansion can occur automatically during normal operation or during standby, shipping, or power failure, *engineering controls shall* be used that are capable of preventing the pressure from exceeding the *design pressure*. Acceptable *engineering controls* include but are not limited to a

a. *pressure relief device* to relieve hydrostatic pressure to another part of the system and
b. reseating *pressure relief valve* to relieve the hydrostatic pressure to an *approved* treatment system.

9.4.3.2 If trapping of liquid with subsequent hydrostatic expansion can occur only during maintenance—i.e., when personnel are performing maintenance tasks—either engineering or *administrative controls shall* be used to relieve or prevent the hydrostatic overpressure.

9.4.4 *Heat exchanger coils* located downstream, or upstream within 18 in. (460 mm), of a heating source and capable of being isolated *shall* be fitted with a *pressure relief device* that discharges to another part of the system in accordance with Section 9.4.3 or outside any enclosed space in accordance with Section 9.7.8. The *pressure relief device shall* be connected at the highest possible location of the heat

exchanger or *piping* between the heat exchanger and its manual isolation valves.

Exceptions to 9.4.4:

1. Relief valves *shall not* be required on *heat exchanger coils* that have a *design pressure* greater than 110% of *refrigerant saturation pressure* when exposed to the maximum heating source temperature.
2. A relief valve *shall not* be required on self-contained or *unit systems* if the volume of the *lowside* of the system, which is shut off by valves, is greater than the specific volume of the *refrigerant* at critical conditions of temperature and pressure as determined by the following formula:

$$V_1/[W_1-(V_2-V_1)/V_{gt}]$$

shall be greater than V_{gc}

where

V_1 = *lowside* volume, ft^3 (m^3)

V_2 = total volume of system, ft^3 (m^3)

W_1 = total weight of *refrigerant* in system, lb (kg)

V_{gt} = specific volume of *refrigerant* vapor at 110°F (43.5°C), ft^3/lb (m^3/kg)

V_{gc} = specific volume at *critical temperature* and pressure, ft^3/lb (m^3/kg)

9.4.5 *Pressure relief devices shall* be direct-pressure actuated or pilot operated. *Pilot-operated pressure relief valves shall* be self actuated, and the main valve *shall* open automatically at the *set pressure* and, if some essential part of the pilot fails, *shall* discharge its full rated capacity.

9.4.6 *Stop valves shall not* be located between a *pressure relief device* and parts of the system protected thereby. A *three-way valve*, used in conjunction with the dual relief valve requirements of Section 9.7.2.3, is not considered a *stop valve*.

9.4.7 When relief valves are connected to discharge to a common discharge *header*, as described in Section 9.7.9.3, a full area *stop valve* is not prohibited from being installed in the discharge pipe between the relief valve and the common *header*. When such a *stop valve* is installed, a locking device *shall* be installed to ensure that the *stop valve* is locked in the open position. This discharge *stop valve shall not* be shut unless one of the following conditions exists:

a. A parallel relief valve is installed that protects the system or vessels.

b. The system or vessels being protected have been depressurized and are vented to the atmosphere.

9.4.8 *Pressure relief devices shall* be connected directly to the *pressure vessel* or other parts of the system protected thereby. These devices *shall* be connected above the liquid *refrigerant* level and installed so that they are accessible for inspection and repair and so that they cannot be readily rendered inoperative.

Exception to 9.4.8: When *fusible plugs* are used on the *highside*, they *shall* be located either above or below the liquid *refrigerant* level.

9.4.9 The seats and discs of *pressure relief devices shall* be constructed of suitable material to resist *refrigerant* corrosion or other chemical action caused by the *refrigerant*. Seats or discs of cast iron *shall not* be used. Seats and discs *shall* be limited in distortion, by pressure or other cause, to a *set pressure* change of not more than 5% in a span of five years.

9.5 Setting of *Pressure Relief Devices*

9.5.1 ***Pressure Relief Valve* Setting.** *Pressure relief valves shall* start to function at a pressure not to exceed the *design pressure* of the parts of the system protected.

Exception to 9.5.1: See Section 9.7.8.3 for relief valves that discharge into other parts of the system.

9.5.2 ***Rupture Member* Setting.** *Rupture members* used in lieu of, or in series with, a relief valve *shall* have a nominal rated rupture pressure not to exceed the *design pressure* of the parts of the system protected. The conditions of application *shall* conform to the requirements of *ASME Boiler and Pressure Vessel Code*, Section VIII, Division 1, paragraph UG-127 [6]. The size of *rupture members* installed ahead of relief valves *shall not* be less than the relief valve inlet.

9.6 Marking of Relief Devices and *Fusible Plugs*

9.6.1 *Pressure relief valves* for *refrigerant* containing components *shall* be set and sealed by the *manufacturer* or an assembler as defined in *ASME Boiler and Pressure Vessel Code*, Section VIII, Division 1 [6]. Each *pressure relief valve shall* be marked by the *manufacturer* or assembler with the data required in *ASME Boiler and Pressure Vessel Code*, Section VIII, Division 1.

Exception to 9.6.1: Relief valves for systems with *design pressures* of 15 psig (103.4 kPa gage) or less *shall* be marked by the *manufacturer* with the pressure setting capacity.

9.6.2 Each *rupture member* for *refrigerant pressure vessels shall* be marked with the data required in *ASME Boiler and Pressure Vessel Code*, Section VIII, Division 1, paragraph UG-129(e) [6].

9.6.3 *Fusible plugs shall* be marked with the melting temperatures in Fahrenheit or Celsius.

9.7 *Pressure Vessel* Protection

9.7.1 *Pressure vessels shall* be provided with overpressure protection in accordance with rules in *ASME Boiler and Pressure Vessel Code*, Section VIII, Division 1 [6].

9.7.2 *Pressure vessels* containing liquid *refrigerant* that are capable of being isolated by *stop valves* from other parts of a *refrigerating system shall* be provided with overpressure protection. *Pressure relief devices* or *fusible plugs shall* be sized in accordance with Section 9.7.5.

9.7.2.1 *Pressure vessels* with an *internal gross volume* of 3 ft^3 (0.085 m^3) or less *shall* use one or more *pressure relief devices* or a *fusible plug*.

9.7.2.2 *Pressure vessels* of more than 3 ft^3 (0.085 m^3) but less than 10 ft^3 (0.285 m^3) *internal gross volume shall* use one or more *pressure relief devices*. *Fusible plugs shall not* be used.

9.7.2.3 *Pressure vessels* of 10 ft^3 (0.285 m^3) or more *internal gross volume shall* use one or more *rupture members* or dual *pressure relief valves* when discharging to the atmosphere. Dual *pressure relief valves shall* be installed with a *three-way valve* to allow testing or repair. When dual relief valves are used, each valve must meet the requirements of Section 9.7.5.

Exceptions to 9.7.2.3: A single relief valve is permitted on *pressure vessels* of 10 ft^3 (0.285 m^3) or more *internal gross volume* when all of the following conditions are met:

1. The relief valves are located on the *lowside* of the system.
2. The vessel is provided with shutoff valves designed to allow pumpdown of the *refrigerant* charge of the *pressure vessel*.
3. Other *pressure vessels* in the system are separately protected in accordance with Section 9.7.2.

9.7.3 For *pressure relief valves* discharging into the *lowside* of the system, a single relief valve (not *rupture member*) of the required relieving capacity *shall not* be used on vessels of 10 ft^3 (0.283 m^3) or more *internal gross volume* except under the conditions permitted in Section 9.7.8.3.

9.7.4 Large vessels containing liquid *refrigerant shall not* be prohibited from using two or more *pressure relief devices* or *dual pressure relief devices* in parallel to obtain the required capacity.

9.7.5 The minimum required discharge capacity of the *pressure relief device* or *fusible plug* for each *pressure vessel shall* be determined by the following formula:

$$C = fDL$$

where

C = minimum required discharge capacity of the *pressure relief device* expressed as mass flow of air, lb/min (kg/s)

D = outside diameter of vessel, ft (m)

L = length of vessel, ft (m)

f = factor dependent upon type of *refrigerant* (see Table 9-1)

Informative Notes:

1. When combustible materials are used within 20 ft (6.1 m) of a *pressure vessel*, multiply the value of f by 2.5.
2. The formula is based on fire conditions. Other heat sources *shall* be calculated separately.

When one *pressure relief device* or *fusible plug* is used to protect more than one *pressure vessel*, the required capacity *shall* be the sum of the capacities required for each *pressure vessel*.

9.7.6 The rated discharge capacity of a *pressure relief device* expressed in pounds of air per minute (kilograms of air per second) *shall* be determined in accordance with *ASME Boiler and Pressure Vessel Code*, Section VIII, Division 1, paragraph UG-131 [6]. All pipe and fittings between the *pressure relief valve* and the parts of the system it protects *shall* have at least the area of the *pressure relief valve* inlet area.

Table 9-1 ***Pressure Relief Devices*** **Capacity Factor**

Refrigerant	Value of *f*
When Used on the *Lowside* of a Limited-Charge *Cascade System*	
R-23, R-170, R-744, R-1150, R-508A, R-508B	1.0 (0.082)
R-13, R-13B1, R-503	2.0 (0.163)
R-14	2.5 (0.203)
Other Applications	
R-718	0.2 (0.016)
R-11, R-32, R-113, R-123, R-142b, R-152a, R-290, R-600, R-600a, R-764	1.0 (0.082)
R-12, R-22, R-114, R-124, R-134a, R-401A, R-401B, R-401C, R-405A, R-406A, R-407C, R-407D, R-407E, R-409A, R-409B, R-411A, R-411B, R-411C, R-412A, R-414A, R-414B, R-500, R-1270	1.6 (0.131)
R-143a, R-402B, R-403A, R-407A, R-408A, R-413A	2.0 (0.163)
R-115, R-402A, R-403B, R-404A, R-407B, R- 410A, R-410B, R-502, R-507A, R-509A	2.5 (0.203)

9.7.7 The rated discharge capacity of a *rupture member* or *fusible plug* discharging to the atmosphere under critical flow conditions in pounds of air per minute (kilograms of air per second) *shall* be determined by the following formulas:

$$C = 0.64 P_1 d^2 \qquad d = 1.25(C/P_1)^{0.5} \qquad \text{(I-P)}$$

$$C = 1.09 \times 10^{-6} P_1 d^2 \qquad d = 958.7(C/P_1)^{0.5} \qquad \text{(SI)}$$

where

C = rated discharge capacity expressed as mass flow of air, lb/min (kg/s)

d = smallest of the internal diameter of the inlet pipe, retaining flanges, *fusible plug*, and *rupture member*, in. (mm)

where for *rupture members*,

P_1 = (rated pressure psig [kPa gage] × 1.10) + 14.7 (101.33)

where for *fusible plugs*,

P_1 = absolute *saturation pressure* corresponding to the stamped temperature melting point of the *fusible plug* or the *critical pressure* of the *refrigerant* used, whichever is smaller, psia (kPa)

9.7.8 Discharge from *Pressure Relief Devices*. Pressure relief systems designed for vapor *shall* comply with Section 9.7.8. Pressure relief systems designed for liquid *shall* comply with Section 9.4.3.

Different *refrigerants shall not* be vented into a common relief *piping* system unless the *refrigerants* are included in a *blend* that is recognized by ASHRAE Standard 34 [2].

9.7.8.1 Discharging Location Interior to Building. *Pressure relief devices*, including *fusible plugs*, serving refrigeration systems *shall* be permitted to discharge to the interior of a building only when all of the following apply:

a. The system contains less than 110 lb (50 kg) of a Group A1 or A2L *refrigerant*.
b. The system contains less than 6.6 lb (3 kg) of a Group A2, B1, B2L, or B2 *refrigerant*.
c. The system does not contain any quantity of a Group A3 or B3 *refrigerant*.
d. The system is to be installed in a *machinery room* as required by Section 7.4.
e. The *refrigerant concentration limits* in Section 7.2 are not exceeded.

Refrigeration systems that do not meet the above requirements *shall* meet the requirements of Sections 9.7.8.2, 9.7.8.3, and 9.7.8.4.

9.7.8.2 Discharging Location Exterior to Building. *Pressure relief devices* designed to discharge external to the refrigeration system *shall* be arranged to discharge outside of a building and comply with all of the following:

a. The point of vent discharge *shall* be located not less than 15 ft (4.57 m) above the adjoining ground level.

Exception to 9.7.8.2(a): Outdoor systems containing Group A1 *refrigerant shall* be permitted to discharge at any elevation where the point of discharge is located in an access controlled area accessible to authorized personnel only.

b. The point of vent discharge *shall* be located not less than 20 ft (6.1 m) from windows, building ventilation openings, pedestrian walkways, or building exits.
c. For heavier-than-air *refrigerants*, the point of vent discharge *shall* be located not less than 20 ft (6.1 m) horizontally from below-grade walkways, entrances, pits, or ramps if a release of the entire system charge into such a space would yield a concentration of *refrigerant* in excess of the *RCL*. The direct discharge of a relief vent into enclosed outdoor spaces, such as a courtyard with walls on all sides, *shall not* be permitted if a release of the entire system charge into such a space would yield a concentration of *refrigerant* in excess of the *RCL*. The volume for the *refrigerant* concentration calculation *shall* be determined using the gross area of the space and a height of 8.2 ft (2.5 m), regardless of the actual height of the enclosed space.
d. The termination point of a vent discharge line *shall* be made in a manner that prevents discharged *refrigerant* from spraying directly onto personnel that might be in the vicinity.
e. The termination point of vent discharge lines *shall* be made in a manner that prevents foreign material or debris from entering the discharge *piping*.
f. Relief vent lines that terminate vertically upward and are subject to moisture entry *shall* be provided with a drip pocket having a minimum of 24 in. (0.6 m) in length and having the size of the vent discharge pipe. The drip pocket *shall* be installed to extend below the first change in vent pipe direction and *shall* be fitted with a valve or drain plug to permit removal of accumulated moisture.

9.7.8.3 Internal Relief. *Pressure relief valves* designed to discharge from a higher-pressure vessel into a lower-pressure vessel internal to the system *shall* comply with all of the following:

a. The *pressure relief valve* that protects the higher-pressure vessel *shall* be selected to deliver capacity in accordance with Section 9.7.5 without exceeding the maximum allowable working pressure of the higher-pressure vessel accounting for the change in mass flow capacity due to the elevated *back pressure*.
b. The capacity of the *pressure relief valve* protecting the part of the system receiving a discharge from a *pressure relief valve* protecting a higher-pressure vessel *shall* be at least the sum of the capacity required in Section 9.7.5 plus the mass flow capacity of the *pressure relief valve* discharging into that part of the system.
c. The *design pressure* of the body of the relief valve used on the higher-pressure vessel *shall* be rated for operation at the *design pressure* of the higher-pressure vessel in both pressure containing areas of the valve.

9.7.8.4 Discharge Location, Special Requirements. Additional requirements for *pressure relief device* discharge location and allowances *shall* apply for specific *refrigerants* as *listed* in this section.

9.7.8.4.1 Water (R-718). Where water is the only *refrigerant*, discharge to a floor drain *shall* be permitted where all of the following conditions are met:

a. The *pressure relief device set pressure* does not exceed 15 psig.
b. The floor drain is sized to handle the flow rate from a single broken tube in any *refrigerant* containing heat exchanger.
c. Either
    1. the AHJ finds it acceptable that the working fluid, corrosion inhibitor, and other additives used in this type of refrigeration system may infrequently be discharged to the sewer system, or
    2. a catch tank, sized to handle the expected discharge, is installed and equipped with a normally closed drain valve and an overflow line to drain.

9.7.9 Relief Discharge *Piping*. The *piping* used for *pressure relief device* discharge *shall* meet the requirements of the following subsections.

9.7.9.1 Discharge *Piping*, General. *Piping* connected to the discharge side of a *fusible plug* or *rupture member shall* have provisions to prevent plugging of the pipe upon operation of a *fusible plug* or *rupture member*.

9.7.9.2 The size of the discharge pipe from a *pressure relief device* or *fusible plug shall not* be less than the outlet size of the *pressure relief device* or *fusible plug*.

9.7.9.3 The maximum length of the discharge *piping* installed on the outlet of *pressure relief devices* and *fusible*

plugs discharging to the atmosphere *shall* be determined using the method in this section.

See *Normative Appendix* E, Table E-1, for the allowable flow capacity of various equivalent lengths of single discharge *piping* vents for conventional *pressure relief valves*.

9.7.9.3.1 The design *back pressure* due to flow in the discharge *piping* at the outlet of *pressure relief devices* and *fusible plugs*, discharging to atmosphere, *shall* be limited by the allowable equivalent length of *piping* determined by the following equations:

$$L = \frac{0.2146 d^5 (P_0^2 - P_2^2)}{f C_r^2} - \frac{d \ln\left(\frac{P_0}{P_2}\right)}{6f} \quad \text{(I-P)}$$

$$L = \frac{7.4381 \times 10^{-15} d^5 (P_0^2 - P_2^2)}{f C_r^2} - \frac{d \ln\left(\frac{P_0}{P_2}\right)}{500f} \quad \text{(SI)}$$

where

L = equivalent length of discharge *piping*, ft (m)

C_r = rated capacity as stamped on the *pressure relief device* in lb/min (kg/s), or in standard cubic feet per minute multiplied by 0.0764, or as calculated in Section 9.7.7 for a *rupture member* or *fusible plug*, or as adjusted for reduced capacity due to *piping* as *specified* by the *manufacturer* of the device, or as adjusted for reduced capacity due to *piping* as estimated by an *approved* method

f = Moody friction factor in fully turbulent flow (***Informative Note:*** See typical values in *Informative Appendix* D).

d = inside diameter of pipe or tube, in. (mm)

ln = natural logarithm

P_2 = absolute pressure at outlet of discharge *piping*, psia (kPa)

P_0 = allowed *back pressure* (absolute) at the outlet of *pressure relief device* (see Section 9.7.9.3.2), psia (kPa)

9.7.9.3.2 Unless the maximum allowable *back pressure* (P_0) is *specified* by the relief valve *manufacturer*, the following maximum allowable *back pressure* values *shall* be used for P_0, where P is the *set pressure* and P_a is atmospheric pressure at the nominal elevation of the installation (Informative Table 9-2):

a. For conventional relief valves: 15% of *set pressure*

$$P_0 = (0.15 \times P) + P_a$$

b. For *balanced relief valves*: 25% of *set pressure*

$$P_0 = (0.25 \times P) + P_a$$

c. For rupture disks alone, *fusible plugs*, or pilot-operated *pressure relief devices*: 50% of *set pressure*

$$P_0 = (0.5 \times P) + P_a$$

Informative Table 9-2 Atmospheric Pressure at Nominal Installation Elevation (P_a)

Elevation above Sea Level (ft)	P_a (psia)	Elevation above Sea Level (m)	P_a (kPa)
0	14.7	0	101
500	14.4	150	99.5
1000	14.2	300	97.8
1500	13.9	450	96.0
2000	13.7	600	94.3
2500	13.4	750	92.6
3000	13.2	900	91.0
3500	12.9	1050	89.3
4000	12.7	1200	87.7
4500	12.5	1350	86.1
5000	12.2	1500	84.6
6000	11.8	1800	81.5
7000	11.3	2100	78.5
8000	10.9	2400	75.6
9000	10.5	2700	72.8
10000	10.1	3000	70.1

For *fusible plugs*, *P shall* be the saturated absolute pressure for the stamped temperature melting point of the *fusible plug* or the *critical pressure* of the *refrigerant* used, whichever is smaller.

9.7.9.3.3 When outlets of two or more relief devices or *fusible plugs*, which are expected to operate simultaneously, connect to a common discharge pipe, the common pipe *shall* be sized large enough to prevent the *back pressure* at each *pressure relief device* from exceeding the maximum allowable *back pressure* in accordance with Section 9.7.9.3.2.

9.8 *Positive Displacement Compressor* Protection. Every *positive displacement compressor* with a *stop valve* in the discharge connection *shall* be equipped with a *pressure relief device* of adequate size and pressure setting, as *specified* by the *compressor manufacturer*, to prevent rupture of the *compressor* or to prevent the pressure from increasing to more than 10% above the maximum allowable working pressure of any other component located in the discharge line between the *compressor* and the *stop valve* or in accordance with Section 9.7.5, whichever is larger. The *pressure relief device shall* discharge into the low-pressure side of the system or in accordance with Section 9.7.8.

Exception to 9.8: Hermetic *refrigerant* motor-*compressors* that are *listed* and have a displacement less than or equal to 50 ft^3/min (1.42 m^3/min).

The relief devices *shall* be sized based on *compressor* flow at the following conditions:

a. ***Compressors* in Single-Stage Systems and High-Stage *Compressors* of Other Systems.** Flow *shall* be calculated

based on 50°F (10°C) saturated suction temperature at the *compressor* suction.

b. **Low-Stage or Booster *Compressors* in *Compound Refrigerating Systems.*** For those *compressors* that are capable of running only when discharging to the suction of a high-stage *compressor*, flow *shall* be calculated based on the saturated suction temperature equal to the design operating intermediate temperature.

c. **Low-Stage *Compressors* in *Cascade Systems*.** For those *compressors* that are located in the lower-temperature stages of *cascade systems*, flow *shall* be calculated based on the suction pressure being equal to the pressure setpoint of the pressure relieving devices that protect the *lowside* of the stage against overpressure.

Exceptions for (a), (b), and (c): The discharge capacity of the *pressure relief device* is allowed to be the minimum regulated flow rate of the *compressor* when all of the following conditions are met:

1. The *compressor* is equipped with capacity regulation.
2. Capacity regulation actuates to minimum flow at 90% of the *pressure relief device* setting.
3. A *pressure limiting device* is installed and set in accordance with the requirements of Section 9.9.

Informative Note: *Informative Appendix* C describes one acceptable method of calculating the discharge capacity of *positive displacement compressor* relief devices.

9.9 Pressure Limiting Devices

9.9.1 When Required. *Pressure limiting devices* complying with Section 9.9 *shall* be provided for *compressors* on all systems operating above atmospheric pressure.

Exception to 9.9.1: *Pressure limiting devices* are not required for *listed* factory-sealed systems containing less than 22 lb (10 kg) of Group A1 *refrigerant*.

9.9.2 Setting. *Pressure limiting devices shall* be set in accordance with one the following:

a. For *positive displacement compressors*:
   1. When systems are protected by a *highside pressure relief device*, the *compressor*'s *pressure limiting device shall* be set at or below 90% of the operating pressure for the *highside pressure relief device*.
   2. When systems are not protected by a *highside pressure relief device*, the *compressor*'s *pressure limiting device shall* be set at or below the system's *highside design pressure*.

b. For *nonpositive displacement compressors*:
   1. When systems are protected by a *highside pressure relief device*, the *compressor*'s *pressure limiting device shall* be set at or below 90% of the operating pressure for the *highside pressure relief device.*
   2. When systems are protected by a *lowside pressure relief device* that is only subject to *lowside* pressure and is provided with a permanent relief path between the systems' *highside* and *lowside*, without intervening valves, the *compressor*'s *pressure limiting device shall* be set at or below the systems' *highside design pressure*.

9.9.3 Location. *Stop valves shall not* be installed between the *pressure imposing element* and *pressure limiting devices* serving *compressors*.

9.9.4 Emergency Stop. Activation of a *pressure limiting device shall* stop the action of the *pressure imposing element*.

9.10 *Refrigerant Piping*, Valves, Fittings, and Related Parts

9.10.1 *Refrigerant piping*, valves, fittings, and related parts having a maximum internal or external *design pressure* greater than 15 psig (103.4 kPa gage) *shall* be *listed* either individually or as part of an assembly or a system by an *approved, nationally recognized laboratory*, or *shall* comply with ASME B31.5 [8] where applicable.

9.10.2 *Refrigerant* Parts in *Air Duct*. Joints and all *refrigerant* containing parts of a *refrigerating system* located in an *air duct* carrying conditioned air to and from an *occupied space shall* be constructed to withstand a temperature of 700°F (371°C) without leaking into the airstream.

9.11 Components Other than *Pressure Vessels* and *Piping*

9.11.1 Every pressure containing component of a *refrigerating system*, other than *pressure vessels*, *piping*, pressure gages, and control mechanisms, *shall* be *listed* either individually or as part of a complete *refrigerating system* or a subassembly by an *approved*, nationally recognized testing laboratory or *shall* be designed, constructed, and assembled to have an *ultimate strength* sufficient to withstand three times the *design pressure* for which it is rated.

Exception to 9.11.1: Water-side components designed to operate at a temperature not exceeding 210°F (99°C) *shall* be exempted from the rules of *ASME Boiler and Pressure Vessel Code*, Section VIII [6] and *shall* be designed, constructed, and assembled to have an *ultimate strength* to withstand 150 psig (1034 kPa) or two times the *design pressure* for which it is rated, whichever is greater.

9.11.2 Liquid-level-gage glass columns *shall* have automatic closing shutoff valves. All such glass columns *shall* be protected against external damage and properly supported.

Exception to 9.11.2: Liquid-level-gage glasses of the bull's-eye type.

9.11.3 When a pressure gage is permanently installed on the *highside* of a *refrigerating system*, its dial *shall* be graduated to at least 1.2 times the *design pressure*.

9.11.4 *Liquid receivers*, if used, or parts of a system designed to receive the *refrigerant* charge during pumpdown *shall* have sufficient capacity to receive the *pumpdown charge*. The liquid *shall not* occupy more than 90% of the volume when the temperature of the *refrigerant* is 90°F (32°C).

Informative Note: The receiver volume is not required to contain the total system charge but is required to contain the amount being transferred. If the environmental temperature is expected to rise above 122°F (50°C), the designer *shall* account for the specific expansion characteristics of the *refrigerant*.

9.12 Service Provisions

9.12.1 All serviceable components of *refrigerating systems shall* be provided with safe access.

9.12.2 *Condensing units* or *compressor units* with enclosures *shall* be provided with safe access without the need to climb over or remove any obstacles or to use portable access devices to get to the equipment.

9.12.3 All systems *shall* have provisions to handle the *refrigerant* charge for service purposes. When required, there *shall* be liquid and vapor transfer valves, a transfer *compressor* or pump, and *refrigerant* storage tanks or appropriate valved connections for removal by a reclaim, recycle, or recovery device.

9.12.4 Systems containing more than 6.6 lb (3 kg) of *refrigerant shall* have *stop valves* installed at

a. the suction inlet of each *compressor*, *compressor unit*, or *condensing unit*;
b. the discharge of each *compressor*, *compressor unit*, or *condensing unit*; and
c. the outlet of each *liquid receiver*.

Exception to 9.12.4: Systems that have a *refrigerant* pumpout function capable of storing the entire *refrigerant* charge, systems that are equipped with the provisions for pumpout of the *refrigerant*, or *self-contained systems*.

9.12.5 Systems containing more than 110 lb (50 kg) of *refrigerant shall* have *stop valves* installed at

a. the suction inlet of each *compressor*, *compressor unit*, or *condensing unit*;
b. the discharge outlet of each *compressor*, *compressor unit*, or *condensing unit*;
c. the inlet of each *liquid receiver*, except for *self-contained systems* or where the receiver is an integral part of the *condenser* or *condensing unit*;
d. the outlet of each *liquid receiver*; and
e. the inlets and outlets of *condensers* when more than one *condenser* is used in parallel in the system.

Exception to 9.12.5: Systems that have a *refrigerant* pumpout function capable of storing the entire *refrigerant* charge, systems that are equipped with the provisions for pumpout of the *refrigerant*, or *self-contained systems.*

9.12.6 *Stop valves shall* be suitably labeled if the components to and from which the valve regulates flow are not in view at the valve location. Valves or *piping* adjacent to the valves *shall* be identified in accordance with ANSI A13.1 [9]. When numbers are used to label the valves, there *shall* be a key to the numbers located within sight of the valves with letters at least 0.5 in. (12.7 mm) high.

9.13 Fabrication

9.13.1 The following are requirements for unprotected *refrigerant*-containing copper pipe or tubing:

a. Copper tubing used for *refrigerant piping shall* conform to one of the following ASTM specifications: B88 [10] types K or L or B280 [11]. Where ASTM B68 [12] and B75 [13] tubing is used, the tube wall thickness *shall* meet or exceed the requirements of ASTM B280 for the given outside diameter.
b. Copper tube *shall* be connected by *brazed joints*, *soldered joints*, or compression fittings or fittings *listed* for refrigeration use.
c. For Group A2L, A2, A3, B1, B2L, B2, and B3 *refrigerants*, protective enclosures or covers *shall* be provided for annealed copper tube erected on the *premises*.

Exception to 9.13.1: No enclosures *shall* be required for connections between a *condensing unit* and the nearest protected riser if such connections are not longer than 6.6 ft (2 m) in length.

9.13.2 Joints on *refrigerant* containing copper tube that are made by the addition of filler metal *shall* be brazed.

Exception to 9.13.2: A1 *refrigerants*.

9.14 Factory Tests

9.14.1 All *refrigerant* containing parts or *unit systems shall* be tested and proved tight by the *manufacturer* at not less than the *design pressure* for which they are rated. *Pressure vessels shall* be tested in accordance with Section 9.3.

9.14.1.1 Testing Procedure. Tests *shall* be performed with dry nitrogen or another nonflammable, nonreactive, dried gas. Oxygen, air, or mixtures containing them *shall not* be used. The means used to build up the test pressure *shall* have either a *pressure limiting device* or a pressure reducing device and a gage on the outlet side. The *pressure relief device shall* be set above the test pressure but low enough to prevent permanent deformation of the system's components.

Exceptions to 9.14.1.1:

1. Mixtures of dry nitrogen, inert gases, nonflammable *refrigerants* are allowed for factory tests.
2. Mixtures of dry nitrogen, inert gases, or a combination of these with flammable *refrigerants* in concentrations not exceeding the lesser of a *refrigerant* weight fraction (mass fraction) of 5% or 25% of the *LFL* are allowed for factory tests.
3. Compressed air without added *refrigerant* is allowed for factory tests, provided the system is subsequently evacuated to less than 1000 µm (132 Pa) before charging with *refrigerant*. The required evacuation level is atmospheric pressure for systems using R-718 (water) or R-744 (carbon dioxide) as the *refrigerant*.

9.14.2 The test pressure applied to the *highside* of each factory-assembled *refrigerating system shall* be at least equal to the *design pressure* of the *highside*. The test pressure applied to the *lowside* of each factory-assembled *refrigerating system shall* be at least equal to the *design pressure* of the *lowside*.

The pressure test on the complete unit *shall not* be conducted at the *lowside design pressure* per Section 9.2 unless the final assembly connections are made per ASME B31.5 [8]. In this case, parts *shall* be individually tested by either the unit *manufacturer* or the *manufacturer* of the part at not less than the *highside design pressure*.

9.14.3 Units with a *design pressure* of 15 psig (103.4 kPa gage) or less *shall* be tested at a pressure not less than 1.33 times the *design pressure* and *shall* be proved leak-tight at not less than the *lowside design pressure*.

9.15 Nameplate. Each *unit system* and each separate *condensing unit*, *compressor*, or *compressor unit* sold for field

assembly in a *refrigerating system shall* carry a nameplate marked with the *manufacturer*'s name, nationally registered trademark or trade name, identification number, *design pressures*, and *refrigerant* for which it is designed. The *refrigerant shall* be designated by the *refrigerant* number ("R-" number) as shown in ASHRAE Standard 34 [2], Table 4-1 or 4-2.

10. OPERATION AND TESTING

10.1 Field Tests

10.1.1 Every *refrigerant* containing part of every system that is erected on the *premises*, except *compressors*, *condensers*, *evaporators*, safety devices, pressure gages, control mechanisms, and systems that are factory tested, *shall* be tested and proved tight after complete installation and before operation. The *highside* and *lowside* of each system *shall* be tested and proved tight at not less than the lower of the *design pressure* or the setting of the *pressure relief device* protecting the *highside* or *lowside* of the system, respectively.

10.1.2 Testing Procedure. Tests *shall* be performed with dry nitrogen or another nonflammable, nonreactive, dried gas. Oxygen, air, or mixtures containing them *shall not* be used. The means used to build up the test pressure *shall* have either a *pressure limiting device* or a pressure reducing device and a gage on the outlet side. The *pressure relief device shall* be set above the test pressure but low enough to prevent permanent deformation of the system's components.

Exceptions to 10.1.2:

1. Mixtures of dry nitrogen, inert gases, or a combination of such with nonflammable *refrigerants* in concentrations of a *refrigerant* weight fraction (mass fraction) not exceeding 5% are allowed for tests.
2. Mixtures of dry nitrogen, inert gases, or a combination of such with flammable *refrigerants* in concentrations not exceeding the lesser of a *refrigerant* weight fraction (mass fraction) of 5% or 25% of the *LFL* are allowed for tests.
3. Compressed air without added *refrigerant* is allowed for tests, provided the system is subsequently evacuated to less than 1000 μm (132 Pa) before charging with *refrigerant*. The required evacuation level is atmospheric pressure for systems using R-718 (water) or R-744 (carbon dioxide) as the *refrigerant*.
4. Systems erected on the *premises* using Group A1 *refrigerant* and with copper tubing not exceeding 0.62 in. (16 mm) outside diameter *shall* be tested by means of the *refrigerant* charged into the system at the saturated vapor pressure of the *refrigerant* at 68°F (20°C) minimum.

10.2 Declaration. A dated declaration of test *shall* be provided for all systems containing 55 lb (25 kg) or more of *refrigerant*. The declaration *shall* give the name of the *refrigerant* and the field test pressure applied to the *highside* and the *lowside* of the system. The declaration of test *shall* be signed by the installer and, if an inspector is present at the tests, the inspector *shall* also sign the declaration. When requested, copies of this declaration *shall* be furnished to the AHJ.

11. GENERAL REQUIREMENTS

11.1 General Restrictions—Safeguards. Means *shall* be taken to adequately safeguard *piping*, controls, and other refrigerating equipment to minimize possible accidental damage or rupture by external sources.

11.2 Signs and Identification

11.2.1 Installation Identification. Each *refrigerating system* erected on the *premises shall* be provided with a legible permanent sign, securely attached and easily accessible, indicating

a. the name and address of the installer,
b. the *refrigerant* number and amount of *refrigerant*,
c. the lubricant identity and amount, and
d. the field test pressure applied.

11.2.2 Controls and *Piping* Identification. Systems containing more than 110 lb (50 kg) of *refrigerant shall* be provided with durable signs having letters not less than 0.5 in. (12.7 mm) in height designating

a. valves or switches for controlling the *refrigerant* flow, the ventilation, and the refrigeration *compressors*; and
b. the kind of *refrigerant* or *secondary coolant* contained in exposed *piping* outside the *machinery room*. Valves, or *piping* adjacent to valves, *shall* be identified in accordance with ANSI A13.1, *Scheme for Identification of Piping Systems* [9].

11.2.3 Changes in *Refrigerant* or Lubricant. When the kind of *refrigerant* or lubricant is changed as provided in Section 7.5.1.8, the signs required by Sections 11.2.1 and 11.2.2 *shall* be replaced, or added if not present, to identify the *refrigerant* and lubricant used.

11.2.4 Each entrance to a refrigerating *machinery room shall* be provided with a legible permanent sign, securely attached and easily accessible, reading "Machinery Room—Authorized Personnel Only." The sign *shall* further communicate that entry is forbidden except by those personnel trained in the emergency procedures required by Section 11.7 when the *refrigerant* alarm, required by Section 8.11.5, has been activated.

11.3 Charging, Withdrawal, and Disposition of *Refrigerants*. No service containers *shall* be left connected to a system except while charging or withdrawing *refrigerant*. *Refrigerants* withdrawn from *refrigerating systems shall* be transferred to *approved* containers only. Except for discharge of *pressure relief devices* and *fusible plugs*, incidental releases due to leaks, purging of noncondensables, draining oil, and other routine operating or maintenance procedures, no *refrigerant shall* be discharged to the atmosphere or to locations such as a sewer, river, stream, or lake.

11.3.1 *Refrigerant* Access. *Refrigerant* circuit access ports located outdoors *shall* be secured to prevent unauthorized access.

11.4 *Containers*. *Containers* used for *refrigerants* withdrawn from a *refrigerating system shall* be as prescribed in the pertinent regulations of the U.S. Department of Transportation and *shall* be carefully weighed each time they are used for this

purpose, and *containers shall not* be filled in excess of the permissible filling weight.

11.5 Storing *Refrigerant*. The total amount of *refrigerant* stored in a *machinery room* in all *containers* not provided with relief valves and *piping* in accordance with Section 9.7 *shall not* exceed 330 lb (150 kg). *Refrigerant shall* be stored in *approved* storage *containers*. Additional quantities of *refrigerant shall* be stored in an *approved* storage facility.

11.6 Maintenance. *Refrigerating systems shall* be maintained by the user in a clean condition, free from accumulations of oily dirt, waste, and other debris, and *shall* be kept accessible at all times.

11.6.1 *Stop Valves*. *Stop valves* connecting *refrigerant* containing parts to atmosphere during shipping, testing, operating, servicing, or standby conditions *shall* be capped, plugged, blanked, or locked closed when not in use.

11.6.2 Calibration of Pressure Measuring Equipment. Pressure measuring equipment *shall* be checked for accuracy and calibrated prior to test and immediately after every occasion of unusually high (full scale) pressure, either by comparison with master gages or a dead-weight pressure gage tester, over the operating range of the equipment.

11.6.3 Periodic Tests. Detectors, alarms, and mechanical ventilating systems *shall* be tested in accordance with *manufacturers*' specifications and the requirements of the AHJ.

11.7 Responsibility for Operation and Emergency Shutdown. It *shall* be the duty of the person in charge of the *premises* on which a *refrigerating system* containing more than 55 lb (25 kg) of *refrigerant* is installed to provide a schematic drawing or panel giving directions for the operation of the system at a location that is convenient to the operators of the equipment.

Emergency shutdown procedures, including precautions to be observed in case of a breakdown or leak, *shall* be displayed on a conspicuous card located as near as possible to the *refrigerant compressor*. These precautions *shall* address

a. instructions for shutting down the system in case of emergency;
b. the name, address, and day and night telephone numbers for obtaining service; and
c. the names, addresses, and telephone numbers of all corporate, local, state, and federal agencies to be contacted as required in the event of a reportable incident.

When a refrigerating *machinery room* is used, the emergency procedures *shall* be posted outside the room, immediately adjacent to each door.

The emergency procedures *shall* forbid entry into the refrigerating *machinery room* when the *refrigerant* alarm required by Section 8.11.5 has been activated, except by persons provided with the appropriate respiratory and other protective equipment and trained in accordance with jurisdictional requirements.

12. PRECEDENCE WITH CONFLICTING REQUIREMENTS

Where there is a conflict between this standard and local building, electrical, fire, mechanical, or other adopted codes, their provisions *shall* take precedence unless otherwise stated in those codes. No provision in this standard *shall* be deemed to restrict the authority of local building, electrical, fire, mechanical, or other officials from approving plans, performing inspections, allowing use of alternative methods and/or materials, or otherwise enforcing adopted codes.

13. LISTED EQUIPMENT

Equipment *listed* by an *approved*, nationally recognized testing laboratory, and identified as part of the listing as being in conformance with this standard, is deemed to meet the design, construction of equipment, and factory test requirement sections of this standard for the *refrigerant* or *refrigerants* for which the equipment was designed.

(This appendix is not part of this standard. It is merely informative and does not contain requirements necessary for conformance to the standard. It has not been processed according to the ANSI requirements for a standard and may contain material that has not been subject to public review or a consensus process. Unresolved objectors on informative material are not offered the right to appeal at ASHRAE or ANSI.)

INFORMATIVE APPENDIX A
INFORMATIVE REFERENCES

This appendix contains a full list of informative references only. A full list of normative references is included in *Normative Appendix* B. References in this standard are numbered in the order in which they appear in the document, so the numbers for the normative references are shown for the convenience of the user.

1. IIAR. 2014. ANSI/IIAR 2, *American National Standard for Safe Design of Closed-Circuit Ammonia Refrigeration Systems*. Arlington, VA: International Institute of Ammonia Refrigeration.
2. Not an informative reference.
3. Not an informative reference.
4. Not an informative reference.
5. Not an informative reference.
6. Not an informative reference.
7. ASHRAE. 2017. *ASHRAE Handbook—Fundamentals*. Atlanta: ASHRAE.
8. Not an informative reference.
9. Not an informative reference.
10. Not an informative reference.
11. Not an informative reference.
12. Not an informative reference.
13. Not an informative reference.
14. NIST. 2013. NIST REFPROP, Version 9.1. National Institute of Standards and Technology, Gaithersburg, MD.
15. IUPAC. 2013. Atomic Weights of the Elements 2013 (IUPAC Technical Report). International Union of Pure and Applied Chemistry, Research Triangle Park, NC.

(This is a normative appendix and is part of this standard.)

NORMATIVE APPENDIX B
NORMATIVE REFERENCES

This appendix contains a complete list of normative references. A complete list of references that are solely informative are included in *Informative Appendix* A. References in this standard are numbered in the order in which they appear in the document, so the numbers for the informative references are shown for the convenience of the user.

1. Not a normative reference.
2. ASHRAE. 2013. ANSI/ASHRAE Standard 34, *Designation and Safety Classification of Refrigerants*. Atlanta: ASHRAE.
3. NFPA. 2014. NFPA 70, *National Electrical Code®*. Quincy, MA: National Fire Protection Association.
4. AHRI. 2015. AHRI 700-2015, *Specifications for Refrigerants* and AHRI Standard 700c-2014, Appendix C to ARI Standard 700—*Analytical Procedures for ARI Standard 700-2014*. Arlington, VA: Air-Conditioning and Refrigeration Institute.
5. UL. 2015. UL 1995, *Heating and Cooling Equipment*, 5th Edition. Northbrook, IL: Underwriters Laboratories, Inc.
6. ASME. 2015. *Boiler and Pressure Vessel Code*, Section VIII, "Rules for Construction of Pressure Vessels," Division 1. New York: American Society of Mechanical Engineers.
7. Not a normative reference.
8. ASME. 2013. ANSI//ASME B31.5, *Refrigeration Piping and Heat Transfer Components*. New York: American Society of Mechanical Engineers.
9. ASME. 2015. ANSI/ASME A13.1, *Scheme for the Identification of Piping Systems*. New York: American Society of Mechanical Engineers.
10. ASTM. 2014. ANSI/ASTM B88, *Standard Specification for Seamless Copper Water Tube*. West Conshohocken, PA: American Society for Testing and Materials.
11. ASTM. 2013. ANSI/ASTM B280, *Standard Specification for Seamless Copper Tube for Air Conditioning and Refrigeration Field Service*. West Conshohocken, PA: American Society for Testing and Materials.
12. ASTM. 2011. ANSI/ASTM B68, *Standard Specification for Seamless Copper Tube, Bright Annealed*. West Conshohocken, PA: American Society for Testing and Materials.

13 ASTM. 2011. ANSI/ASTM B75, *Standard Specification for Seamless Copper Tube*. West Conshohocken, PA: American Society for Testing and Materials.

14. Not a normative reference.
15. Not a normative reference.

(This appendix is not part of this standard. It is merely informative and does not contain requirements necessary for conformance to the standard. It has not been processed according to the ANSI requirements for a standard and may contain material that has not been subject to public review or a consensus process. Unresolved objectors on informative material are not offered the right to appeal at ASHRAE or ANSI.)

INFORMATIVE APPENDIX C METHOD FOR CALCULATING DISCHARGE CAPACITY OF POSITIVE DISPLACEMENT COMPRESSOR PRESSURE RELIEF DEVICE

The following calculation method provides the required discharge capacity of the *compressor pressure relief device* in Section 9.8*:

$$W_v = \frac{Q \times \mathrm{PL} \times \eta_v}{v_g} \qquad \text{(C-1)}$$

where

W_r = mass flow of *refrigerant*, $\mathrm{lb_m}$/min (kg/s)

Q = swept volume flow rate of *compressor*, $\mathrm{ft^3}$/min ($\mathrm{m^3}$/s)

PL = fraction of *compressor* capacity at minimum regulated flow

η_v = volumetric efficiency (assume 0.9 unless actual volumetric efficiency at relieving pressure is known)

v_g = specific volume of *refrigerant* vapor as *specified* in Section 9.8, $\mathrm{ft^3/lb_m}$ ($\mathrm{m^3}$/kg)

Next, find the relieving capacity in mass flow of air W_a for an ASME-rated (Reference 6 in *Normative Appendix* B) *pressure relief device*:

$$W_a = W_r \times r_w \qquad \text{(C-2)}$$

$$r_w = \frac{C_a}{C_r}\sqrt{\frac{T_r}{T_a}}\sqrt{\frac{M_a}{M_r}} \qquad \text{(C-3)}$$

where

r_w = *refrigerant*-to-standard-air-mass-flow conversion factor (see Table C-1)

M_a = molar mass of air = 28.97

M_r = molar mass of *refrigerant* (see Table C-1)

T_a = absolute temperature of the air = 520°R (289 K)

T_r = absolute temperature of the *refrigerant* = 510°R (283 K)

C_a = constant for air = 356

* Section 9.8 permits the discharge capacity of the *pressure relief device* to be the minimum regulated flow rate of the *compressor* when the following conditions are met: (a) the *compressor* is equipped with capacity regulation, (b) capacity regulation actuates to minimum flow at 90% of the *pressure relief device* setting, and (c) the *pressure limiting device* is installed and set in accordance with the requirements of Section 9.9.

Table C-1 Constants for Calculating Discharge Capacity

Refrigerant	k [a]	Molar Mass [b]	C_r	r_w
R-11	1.137	137.4	330.7	0.49
R-12	1.205	120.9	337.7	0.51
R-13	2.053	104.5	403.6	0.46
R-22	1.319	86.5	348.8	0.59
R-23	2.742	70.0	439.3	0.52
R-113	1.081	187.4	324.7	0.43
R-114	1.094	170.9	326.1	0.45
R-123	1.104	152.9	327.1	0.47
R-134a	1.196	102.0	336.8	0.56
R-236fa	1.101	152.0	326.8	0.47
R-245fa	1.107	134.0	327.5	0.50
R-290	1.235	44.1	340.8	0.84
R-404A	1.279	97.6	345.0	0.56
R-407C	1.270	86.2	344.1	0.59
R-410A	1.434	72.6	359.0	0.62
R-500	1.236	99.3	340.8	0.56
R-502	1.264	111.6	343.6	0.52
R-507A	1.284	98.9	345.5	0.55
R-600	1.122	58.1	329.2	0.76
R-718	1.328	18.0	349.6	1.28
R-744	2.690	44.0	437.0	0.65

a. Source: NIST REFPROP, Standard Reference Database, v9.1, 2013 [14]
b. Source: IUPAC Atomic Weights, 2013 [15]

C_r = constant for *refrigerant* as determined from Equation C-4

$$C_r = 520\sqrt{k\left(\frac{2}{k+1}\right)^{\frac{k+1}{k-1}}} \qquad \text{(C-4)}$$

where

k = ratio of specific heats (C_p/C_v)

C_p = constant-pressure specific heat of *refrigerant* at a *refrigerant* quality of 1 at 50°F (10°C)

C_v = constant-volume specific heat of *refrigerant* at a *refrigerant* quality of 1 at 50°F (10°C)

Constants for several *refrigerants* are listed in Table C-1.

Example

Determine the flow capacity of a *pressure relief device* for a R-410A *compressor* with a swept volume Q of 341 $\mathrm{ft^3}$/min (0.1609 $\mathrm{m^3}$/s). The *compressor* is equipped with capacity control that is actuated at 90% of the *pressure relief device set pressure* and has a minimum regulated flow of 10%.

Q = 341 $\mathrm{ft^3}$/min

Q = 0.16095 $\mathrm{m^3}$/s

η_v = 0.90, assumed

PL = 0.1

$v_{g@50°F}$ = 1.1979 ft3/lbm (I-P)

$v_{g@10°C}$ = 0.0748 m^3/kg (SI)

$$W_r = \frac{341\dfrac{\text{ft}^3}{\text{min}} \times 0.1 \times 0.9}{1.1979\dfrac{\text{ft}^3}{\text{lb}_\text{m}}} = 25.62\frac{\text{lb}_\text{m}}{\text{min}} \quad \text{(I-P [see C-1])}$$

$$W_r = \frac{0.1609\dfrac{\text{m}^3}{\text{s}} \times 0.1 \times 0.9}{0.0748\dfrac{\text{m}^3}{\text{kg}}} = 0.1936\frac{\text{kg}}{\text{s}} \quad \text{(SI [see C-1])}$$

$$W_a = W_r \times r_w = 25.62 \times 0.62 = 15.88\frac{\text{lb}_\text{m}}{\text{min}} \text{ of air}$$

(I-P [see C-2])

$$W_a = W_r \times r_w = 0.1936 \times 0.62 = 0.12\frac{\text{kg}}{\text{s}} \text{ of air}$$

(SI [see C-2])

Converting to standard cubic feet per minute, where V_a = specific volume of air = 13.1 ft^3/lb$_\text{m}$ (0.818 m^3/kg) for dry air at 60°F (15.6°C):

SCFM = 13.1 (15.88) = 208.02 ft^3/min (I-P)

SCFM = 0.818 (0.12) = 0.098 m^3/s (SI)

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INFORMATIVE APPENDIX D
TYPICAL MOODY FRICTION FACTORS FOR USE IN RELIEF PIPING LINE LENGTH LIMIT

Table D-1 Typical Moody Friction Factors (*f*) for Fully Turbulent Flow

Tubing OD, in.	DN, mm	ID, in.	*f*
3/8	8	0.315	0.0136
1/2	10	0.430	0.0128
5/8	13	0.545	0.0122
3/4	16	0.666	0.0117
7/8	20	0.785	0.0114
1 1/8	25	1.025	0.0108
1 3/8	32	1.265	0.0104
1 5/8	40	1.505	0.0101

Piping NPS, in.	DN, mm	ID, in.	*f*
1/2	15	0.622	0.0259
3/4	20	0.824	0.0240
1	25	1.049	0.0225
1 1/4	32	1.380	0.0209
1 1/2	40	1.610	0.0202
2	50	2.067	0.0190
2 1/2	65	2.469	0.0182
3	80	3.068	0.0173
4	100	4.026	0.0163
5	125	5.047	0.0155
6	150	6.065	0.0149

(This is a normative appendix and is part of this standard.)

NORMATIVE APPENDIX E
ALLOWABLE EQUIVALENT LENGTH OF DISCHARGE PIPING

Table E-1 ***Pressure Relief Valve*** **Discharge Line Capacity (lb/min of air) of Various Discharge Line Lengths**

Set Pressure, psig	Length, ft	Nominal Pipe Size, NPS in. (DN mm) 0.5 (15)	0.75 (20)	1 (25)	1.25 (32)	1.5 (40)	2 (50)	2.5 (65)	3 (80)	4 (100)	5 (125)	6 (150)
5	2	2.8	5.8	10.7	21.3	31.4	57.8	88.8	148.0	278.9	469	704
5	3	2.3	4.8	9.0	18.1	26.8	49.9	77.3	130.4	249.8	426	647
5	4	2.0	4.2	7.9	16.0	23.7	44.5	69.4	117.8	228.2	393	601
5	5	1.8	3.8	7.1	14.4	21.5	40.6	63.5	108.3	211.4	367	564
5	6	1.7	3.5	6.6	13.3	19.8	37.5	58.9	100.8	197.8	346	533
5	8	1.5	3.0	5.7	11.6	17.4	33.1	52.0	89.5	177.0	312	484
5	10	1.3	2.7	5.1	10.5	15.7	29.9	47.1	81.3	161.7	286	446
5	15	1.1	2.2	4.2	8.6	12.9	24.7	39.2	67.9	135.9	243	380
5	20	0.9	1.9	3.7	7.5	11.3	21.6	34.2	59.4	119.5	214	337
5	25	0.8	1.7	3.3	6.7	10.1	19.4	30.8	53.5	107.9	194	306
5	30	0.8	1.6	3.0	6.2	9.3	17.8	28.2	49.1	99.1	179	282
5	40	0.7	1.4	2.6	5.3	8.0	15.4	24.5	42.8	86.5	156	247
5	60	0.5	1.1	2.1	4.4	6.6	12.6	20.1	35.1	71.2	129	205
5	100	0.4	0.9	1.7	3.4	5.1	9.8	15.6	27.3	55.6	101	160
5	160	0.3	0.7	1.3	2.7	4.0	7.8	12.4	21.7	44.1	80	127
5	250	0.3	0.6	1.0	2.1	3.2	6.2	9.9	17.4	35.3	64	102
15	2	4.6	9.3	16.7	32.0	46.0	81.6	121.8	196.5	355.2	577	849
15	3	3.9	8.0	15.5	28.3	41.0	74.0	111.6	182.3	334.5	550	815
15	4	3.5	7.1	13.0	25.6	37.4	68.1	103.6	170.8	317.1	526	784
15	5	3.1	6.5	11.9	23.6	34.6	63.5	97.1	161.2	302.2	506	757
15	6	2.9	6.0	11.0	22.0	32.3	59.7	91.7	153.1	289.2	487	732
15	8	2.5	5.2	9.7	19.5	28.9	53.8	83.2	140.0	267.5	455	689
15	10	2.3	4.7	8.8	17.8	26.3	49.3	76.7	129.7	250.1	429	683

Set Pressure, psig	Length, ft	Nominal Pipe Size, NPS in. (DN mm) 0.5 (15)	0.75 (20)	1 (25)	1.25 (32)	1.5 (40)	2 (50)	2.5 (65)	3 (80)	4 (100)	5 (125)	6 (150)
15	15	1.9	3.9	7.3	14.8	22.1	41.7	65.3	111.6	218.0	379	583
15	20	1.6	3.4	6.4	13.0	19.4	36.8	57.9	99.4	195.8	344	532
15	25	1.5	3.1	5.7	11.7	17.5	33.3	52.5	90.5	179.3	316	492
15	30	1.3	2.8	5.3	10.7	16.1	30.7	48.4	83.6	166.3	295	460
15	40	1.2	2.4	4.6	9.4	14.0	26.8	42.4	73.5	147.1	262	411
15	60	1.0	2.0	3.8	7.7	11.6	22.1	35.1	61.0	122.7	220	347
15	100	0.7	1.5	2.9	6.0	9.0	17.3	27.5	47.9	96.8	175	276
15	160	0.6	1.2	2.3	4.7	7.1	13.7	21.8	38.1	77.3	140	222
15	250	0.5	1.0	1.9	3.8	5.7	11.0	17.5	30.6	62.3	113	179
25	2	5.7	11.3	20.0	37.6	53.5	93.2	137.5	219.2	390.5	628	918
25	3	4.9	9.9	17.8	34.0	48.8	86.5	128.8	207.5	374.4	608	893
25	4	4.4	8.9	16.2	31.3	45.3	81.0	121.6	197.6	360.1	589	869
25	5	4.0	8.2	14.9	29.1	42.3	76.4	115.5	188.9	347.3	572	848
25	6	3.7	7.6	13.9	27.4	39.9	72.6	110.2	181.3	335.8	556	828
25	8	3.3	6.7	12.4	24.6	36.1	66.4	101.5	168.5	315.9	529	791
25	10	3.0	6.1	11.3	22.6	33.3	61.5	94.6	158.1	299.1	505	759
25	15	2.5	5.1	9.5	19.1	28.3	52.9	82.1	138.7	266.6	457	694
25	20	2.1	4.5	8.3	16.8	25.0	47.1	73.5	125.0	242.9	420	643
25	25	1.9	4.0	7.5	15.2	22.7	42.9	67.1	114.7	224.5	391	602
25	30	1.8	3.7	6.9	14.0	20.9	39.6	62.2	106.6	209.8	367	568
25	40	1.5	3.2	6.0	12.2	18.3	34.8	54.9	94.5	187.3	331	514
25	60	1.3	2.6	4.9	10.1	15.1	28.9	45.7	79.1	158.0	281	440
25	100	1.0	2.0	3.8	7.9	11.8	22.7	36.0	62.5	125.8	226	356

SI Conversions: kPa = psig × 6.895; mm = in. × 25.4; kg/s = lb/min × 0.007559; m = ft × 0.3048

Table E-1 ***Pressure Relief Valve*** **Discharge Line Capacity (lb/min of air) of Various Discharge Line Lengths** ***(Continued)***

Set Pressure, psig	Length, ft	Nominal Pipe Size, NPS in. (DN mm) 0.5 (15)	0.75 (20)	1 (25)	1.25 (32)	1.5 (40)	2 (50)	2.5 (65)	3 (80)	4 (100)	5 (125)	6 (150)
25	160	0.8	1.6	3.1	6.3	9.4	18.1	28.7	50.0	101.1	183	289
25	250	0.6	1.3	2.4	5.0	7.6	14.5	32.1	40.3	81.7	148	235
50	2	7.6	14.7	25.4	46.5	65.3	111.7	162.8	256	451	718	1045
50	3	6.8	13.2	23.2	43.4	61.4	106.3	156.1	248	439	704	1027
50	4	6.1	12.2	21.6	40.8	58.1	101.6	150.2	240	429	691	1011
50	5	5.7	11.3	20.2	38.6	55.2	97.4	144.9	233	419	678	996
50	6	5.3	10.6	19.1	36.7	52.8	93.8	140.1	226	410	666	981
50	8	4.7	9.5	17.3	33.6	48.7	87.5	131.8	215	393	644	953
50	10	4.3	8.7	15.9	31.2	45.5	82.4	124.8	205	378	624	927
50	15	3.6	7.4	13.6	26.9	39.6	72.7	113.3	185	347	582	872
50	20	3.1	6.5	12.0	24.0	35.5	65.8	101.4	170	323	547	825
50	25	2.8	5.9	10.9	21.9	32.4	60.5	93.8	158	303	517	785
50	30	2.6	5.4	10.0	20.3	30.1	56.3	87.6	148	286	492	750
50	40	2.3	4.7	8.8	17.8	26.6	50.1	78.3	133	260	451	692
50	60	1.9	3.9	7.3	14.8	22.1	42.0	66.0	113	224	393	608
50	100	1.4	3.0	5.7	11.6	17.4	33.3	52.6	91	182	323	504
50	160	1.1	2.4	4.5	9.3	13.9	26.7	42.3	73	148	265	416
50	250	0.9	1.9	3.6	7.5	11.2	21.5	34.2	59	120	217	342
75	2	9.1	17.2	29.4	53.3	74.3	126.0	182.7	286	501	795	1154
75	3	8.2	15.8	27.3	50.4	70.7	121.2	176.9	279	491	783	1140
75	4	7.5	14.6	25.7	47.8	67.6	116.9	171.6	272	482	772	1127
75	5	7.0	13.7	24.3	45.7	64.8	113.1	166.8	266	474	762	1114
75	6	6.5	13.0	23.1	43.7	62.4	109.6	162.3	260	466	751	1101
75	8	5.9	11.8	21.1	40.6	58.3	103.4	154.4	249	450	732	1077
75	10	5.4	10.8	19.6	38.0	54.9	98.2	147.5	240	437	714	1054

Set Pressure, psig	Length, ft	Nominal Pipe Size, NPS in. (DN mm) 0.5 (15)	0.75 (20)	1 (25)	1.25 (32)	1.5 (40)	2 (50)	2.5 (65)	3 (80)	4 (100)	5 (125)	6 (150)
75	15	4.5	9.2	16.9	33.2	48.4	88.0	133.7	220	407	675	1004
75	20	4.0	8.2	15.1	29.9	43.8	80.5	123.1	204	383	641	960
75	25	3.6	7.4	13.7	27.4	40.3	74.6	114.8	192	363	612	921
75	30	3.3	6.8	12.7	25.4	37.6	69.8	107.9	181	345	587	887
75	40	2.9	6.0	11.2	22.5	33.4	62.5	97.2	164	317	544	828
75	60	2.4	5.0	9.3	16.8	28.0	52.9	82.8	141	276	481	739
75	100	1.9	3.9	7.3	14.8	22.2	42.2	66.5	115	227	401	623
75	160	1.5	3.1	5.8	11.9	17.8	34.0	53.8	93	186	332	520
75	250	1.2	2.5	4.7	9.6	14.4	27.5	43.6	76	153	274	432
100	2	10.3	19.4	32.9	59.3	82.2	138.8	200.8	314	547	868	1258
100	3	9.4	17.9	30.9	56.4	78.9	134.4	195.4	307	539	857	1246
100	4	8.7	16.8	29.2	54.0	75.9	130.3	190.4	301	531	847	1234
100	5	8.1	15.8	27.8	51.8	73.2	126.6	185.9	295	523	837	1222
100	6	7.6	15.0	26.5	49.9	70.8	123.2	181.7	289	515	828	1210
100	8	6.9	13.7	24.5	46.6	66.6	117.2	174.0	279	501	810	1188
100	10	6.3	12.7	22.8	43.9	63.1	112.0	167.2	270	488	793	1167
100	15	5.4	10.9	19.9	38.7	56.3	101.4	153.1	250	459	756	1120
100	20	4.7	9.7	17.8	35.1	51.3	93.4	142.1	234	435	723	1077
100	25	4.3	8.8	16.3	32.3	47.4	87.0	133.2	221	415	694	1039
100	30	4.0	8.2	15.1	30.1	44.3	81.8	125.8	210	397	668	1005
100	40	3.5	7.2	13.3	26.7	39.5	73.7	114.0	192	367	625	946
100	60	2.9	5.9	11.1	22.4	33.4	62.7	97.9	166	323	558	853
100	100	2.2	4.7	8.7	17.8	26.6	50.4	79.2	136	268	471	728
100	160	1.8	3.7	7.0	14.3	21.4	40.7	64.3	111	222	393	614
100	250	1.4	3.0	5.6	11.5	17.3	33.0	52.3	91	182	326	513

SI Conversions: kPa = psig × 6.895; mm = in. × 25.4; kg/s = lb/min × 0.007559; m = ft × 0.3048

Table E-1 ***Pressure Relief Valve*** **Discharge Line Capacity (lb/min of air) of Various Discharge Line Lengths** ***(Continued)***

Set Pressure, psig	Length, ft	Nominal Pipe Size, NPS in. (DN mm) 0.5 (15)	0.75 (20)	1 (25)	1.25 (32)	1.5 (40)	2 (50)	2.5 (65)	3 (80)	4 (100)	5 (125)	6 (150)
150	2	12.5	23.3	39.2	70.1	96.8	162.7	234.5	366	636	1006	1457
150	3	11.6	21.8	37.2	67.4	93.7	158.5	229.6	360	628	996	1446
150	4	10.8	20.6	35.5	64.9	90.8	154.7	225.1	354	621	987	1435
150	5	10.2	19.6	34.0	62.8	88.1	151.2	220.7	348	613	979	1425
150	6	9.6	18.7	32.7	60.8	85.7	147.8	216.6	343	606	970	1414
150	8	8.8	17.3	30.5	57.3	81.4	141.8	209.1	333	593	954	1394
150	10	8.1	16.1	28.7	54.4	77.7	136.5	202.3	324	581	938	1375
150	15	6.9	14.0	25.2	48.7	70.3	125.4	187.8	304	553	902	1330
150	20	6.2	12.5	22.8	44.5	64.6	116.6	176.0	288	529	870	1289
150	25	5.6	11.4	21.0	41.2	60.2	109.4	166.2	274	507	841	1251
150	30	5.2	10.6	19.5	38.6	56.5	103.4	157.9	261	488	815	1217
150	40	4.5	9.4	17.3	34.5	50.8	93.9	144.5	241	456	769	1156
150	60	3.8	7.8	14.5	29.2	43.3	80.8	125.4	212	407	696	1058
150	100	2.9	6.1	11.5	23.3	34.7	65.6	102.7	175	343	597	918
150	160	2.3	4.9	9.2	18.7	28.0	53.3	84.0	145	286	505	785
150	250	1.9	3.9	7.4	15.2	22.7	43.4	68.6	119	238	423	662
200	2	14.6	26.9	45.0	80.2	110.6	185.2	266.6	415	721	1139	1649
200	3	13.6	25.4	43.1	77.5	107.4	181.2	261.9	409	713	1130	1638
200	4	12.7	24.2	41.3	75.1	104.6	177.4	257.4	404	706	1121	1628
200	5	12.0	23.1	39.8	72.8	101.9	173.9	253.1	398	699	1113	1618
200	6	11.5	22.1	38.4	70.8	99.4	170.6	249.1	393	692	1105	1608
200	8	10.5	20.5	36.0	67.2	95.0	164.5	241.5	383	679	1089	1588
200	10	9.7	19.2	34.0	64.1	91.1	159.0	234.6	374	667	1073	1570
200	15	8.4	16.8	30.2	57.9	83.2	147.3	219.6	354	639	1038	1525
200	20	7.5	15.2	27.5	53.2	77.0	137.9	207.2	337	614	1005	1485
200	25	6.8	13.9	24.3	49.5	72.0	130.1	196.6	322	592	967	1447
200	30	6.3	12.9	23.6	46.5	67.9	123.4	187.6	309	572	949	1412
200	40	5.6	11.4	21.1	41.8	61.4	112.8	172.6	287	538	901	1349
200	60	4.6	9.6	17.7	35.5	52.5	97.7	151.1	254	484	823	1245
200	100	3.6	7.5	14.1	28.5	42.4	79.9	124.7	212	413	714	1094
200	160	2.9	6.0	11.3	23.0	34.4	65.2	102.5	176	347	610	944
200	250	2.3	4.9	9.1	18.6	27.9	53.3	84.1	145	290	514	802
250	2	16.5	30.4	50.7	89.9	123.8	207.0	297.7	463	803	1268	1836
250	3	15.5	28.8	48.6	87.2	120.7	203.0	293.0	457	796	1260	1826
250	4	14.6	27.5	46.9	84.7	117.8	199.3	288.5	452	789	1251	1815
250	5	13.8	26.4	45.2	82.4	115.1	195.7	284.2	446	782	1243	1805
250	6	13.2	25.4	43.8	80.3	112.5	192.3	280.2	441	775	1234	1795
250	8	12.2	23.6	41.3	76.6	107.9	186.1	272.5	431	762	1219	1776
250	10	11.3	22.2	39.1	73.3	103.9	180.4	265.4	422	750	1203	1757
250	15	9.8	19.6	35.0	66.7	95.4	168.2	249.8	401	721	1167	1713
250	20	8.8	17.7	31.9	61.5	88.7	158.1	236.7	383	696	1135	1672
250	25	8.0	16.3	29.5	57.5	83.3	149.7	225.5	368	673	1104	1634
250	30	7.4	15.1	27.6	54.1	78.7	142.5	215.7	354	652	1076	1598
250	40	6.5	13.4	24.7	48.8	71.5	130.7	199.5	330	616	1026	1533
250	60	5.4	11.3	20.9	41.7	61.5	114.0	175.6	294	558	944	1423
250	100	4.3	8.9	16.6	33.6	49.9	93.7	145.9	248	479	826	1261
250	160	3.4	7.1	13.4	27.2	40.6	76.8	120.5	207	406	710	1096
250	250	2.7	5.8	10.8	22.1	33.0	62.9	99.2	171	340	602	937
300	2	18.4	33.7	56.1	99.4	136.7	228.3	328	510	884	1395	2019
300	3	17.3	32.1	54.0	96.0	133.5	224.2	323	504	877	1386	2009

SI Conversions: kPa = psig × 6.895; mm = in. × 25.4; kg/s = lb/min × 0.007559; m = ft × 0.3048

Table E-1 ***Pressure Relief Valve*** **Discharge Line Capacity (lb/min of air) of Various Discharge Line Lengths** ***(Continued)***

Set Pressure, psig	Length, ft	0.5 (15)	0.75 (20)	1 (25)	1.25 (32)	1.5 (40)	2 (50)	2.5 (65)	3 (80)	4 (100)	5 (125)	6 (150)
		Nominal Pipe Size, NPS in. (DN mm)										
300	4	16.4	30.8	52.2	94.1	130.6	220.4	319	498	869	1378	1998
300	5	15.6	29.6	50.5	91.7	127.8	216.8	314	493	862	1369	1988
300	6	14.9	28.5	49.0	89.6	125.2	213.4	310	488	856	1361	1978
300	8	13.8	26.6	46.3	85.6	120.4	206.9	302	478	843	1345	1959
300	10	12.8	25.1	44.1	82.2	116.2	201.0	295	468	830	1330	1940
300	15	11.2	22.2	39.6	75.1	107.2	188.3	279	447	801	1293	1895
300	20	10.0	20.1	36.2	69.6	100.1	177.7	265	428	775	1260	1853
300	25	9.2	18.6	33.6	65.2	94.2	168.7	253	412	751	1229	1814
300	30	8.5	17.3	31.5	61.5	89.2	160.9	243	397	729	1200	1777
300	40	7.5	15.4	28.2	55.6	81.3	148.2	225	372	691	1148	1710
300	60	6.3	12.9	23.9	47.7	70.2	129.7	199	333	639	1061	1595
300	100	4.9	10.3	19.1	38.5	57.2	107.1	167	282	544	934	1422
300	160	3.9	8.2	15.4	31.3	46.6	88.1	138	236	463	807	1243
300	250	3.2	6.6	12.5	25.4	38.0	72.3	114	196	389	687	1068
350	2	20.3	37.0	61.4	108.6	149	249	358	556	963	1519	2199
350	3	19.1	35.3	59.3	105.8	146	245	353	550	956	1510	2189
350	4	18.1	33.9	57.4	103.3	143	241	348	544	949	1502	2178
350	5	17.3	32.7	55.7	100.9	140	237	344	539	941	1493	2168
350	6	16.6	31.5	54.1	98.6	137	234	340	534	935	1484	2158
350	8	15.3	29.6	51.3	94.5	132	227	331	523	921	1468	2139
350	10	14.4	28.0	48.9	90.9	128	221	324	514	908	1452	2120
350	15	12.5	24.8	44.1	83.5	119	208	307	492	879	1414	2075
350	20	11.3	22.6	40.5	77.6	111	196	293	473	852	1379	2032
350	25	10.3	20.8	37.6	72.8	105	187	280	455	827	1347	1992
350	30	9.6	19.4	35.3	68.8	99	178	269	440	804	1317	1954
350	40	8.5	17.3	31.7	62.4	91	163	250	413	764	1262	1885
350	60	7.1	14.6	26.9	53.7	79	145	222	372	699	1170	1765
350	100	5.6	11.6	21.6	43.5	64	120	186	316	607	1034	1582
350	160	4.5	9.3	17.4	35.4	52	99	155	266	519	897	1390
350	250	3.6	7.5	14.1	28.8	43	81	128	222	438	766	1200
400	2	22.0	40.2	66.6	117.7	161.7	269.6	387	601	1041	1642	2376
400	3	20.9	38.5	64.5	114.8	158.4	265.5	382	595	1034	1633	2366
400	4	19.8	37.0	62.5	112.2	155.3	261.5	378	589	1026	1625	2355
400	5	18.9	35.7	60.7	109.7	152.4	257.7	373	584	1019	1616	2345
400	6	18.2	34.5	59.1	107.4	149.6	254.1	369	578	1012	1608	2335
400	8	16.9	32.5	56.1	103.1	144.5	247.3	360	568	999	1591	2315
400	10	15.8	30.7	53.6	99.3	139.9	241.0	353	558	986	1575	2295
400	15	13.9	27.4	48.5	91.5	130.1	227.1	335	535	955	1537	2249
400	20	12.5	24.9	44.6	85.2	122.0	215.4	320	515	927	1502	2205
400	25	11.4	23.0	41.6	80.1	115.3	205.4	307	497	902	1469	2164
400	30	10.6	21.5	39.0	75.8	109.6	196.6	296	481	878	1438	2125
400	40	9.4	19.2	35.1	68.9	100.4	182.0	276	453	836	1382	2052
400	60	7.9	16.2	26.9	59.4	87.2	160.4	246	409	767	1286	1927
400	100	6.2	12.9	24.0	48.3	71.5	133.4	207	349	669	1143	1734
400	160	5.0	10.4	19.4	39.3	58.5	110.3	173	294	574	996	1529
400	250	4.0	8.4	15.7	32.0	47.9	90.9	143	246	468	854	1324

SI Conversions: kPa = psig × 6.895; mm = in. × 25.4; kg/s = lb/min × 0.007559; m = ft × 0.3048

Table E-1 ***Pressure Relief Valve*** **Discharge Line Capacity (lb/min of air) of Various Discharge Line Lengths** ***(Continued)***

Set Pressure, psig	Length, ft	Nominal Pipe Size, NPS in. (DN mm)							
		0.5 (15)	0.75 (20)	1 (25)	1.25 (32)	1.5 (40)	2 (50)	2.5 (65)	3 (80)
450	5	20.6	38.7	65	118	164	277	401	—
450	10	17.2	33.4	58	108	151	260	380	—
450	15	15.2	29.9	53	99	141	245	362	—
450	20	13.7	27.3	48.7	93	132	233	346	—
450	25	12.6	25.2	44.9	87	125	222	333	—
450	30	11.7	23.6	42.7	83	119	213	320	—
450	40	10.4	21.1	38.5	76	109	198	299	493
450	60	8.7	17.8	32.8	65	95	175	267	446
450	100	6.9	14.2	26.4	53	78	146	226	382
450	160	5,5	11,4	21,4	43,3	64	120	189	323
450	250	4.4	9.2	17.3	35.3	52	99	156	269
500	5	22.2	41.6	70.5	127	176	297	430	—
500	10	18.7	36.1	62.8	116	162	279	408	—
500	15	16.5	32.4	57.1	107	152	264	389	—
500	20	14.9	29.6	52.8	100	142	251	373	—
500	25	13.7	27.4	49.3	94	134	240	359	—
500	30	12.7	25.7	46.4	88	129	230	346	—

Set Pressure, psig	Length, ft	Nominal Pipe Size, NPS in. (DN mm)							
		0.5 (15)	0.75 (20)	1 (25)	1.25 (32)	1.5 (40)	2 (50)	2.5 (65)	3 (80)
500	40	11.3	23.0	41.9	82	118	214	324	
500	60	9.5	21.0	35.8	71	103	189	290	482
500	100	7.5	15.5	28.8	58	85	158	245	414
500	160	6.0	11.2	23.3	47.3	70	131	206	352
500	250	4.8	10.1	18.8	38.6	57	108	171	295
550	5	23.8	44.5	76	135	188	316	457	—
550	10	20.1	38.8	67	124	174	298	435	—
550	15	17.8	34.9	61	115	162	282	416	—
550	20	16.1	31.9	57	108	153	269	399	—
550	25	14.8	29.6	53	102	145	258	384	—
550	30	13.8	27.7	50.0	96	139	247	370	—
550	40	12.2	24.8	45.2	88	127	230	347	—
550	60	10.2	21.0	38.7	76	111	216	312	—
550	100	8.1	16.8	31.3	62	92	171	264	447
550	160	6.5	13.5	25.3	51	75	142	227	380
550	250	5.3	10.9	20.5	42	62	117	184	319

Set Pressure, psig	Length. ft	Type L Copper Tubing Outer Diameter (OD), in.							
		3/8	1/2	5/8	3/4	7/8	1-1/8	1-3/8	1-5/8
100	5	2.1	4.3	7.4	11.7	16.9	30.5	48.1	69.7
100	10	—	3.4	6.1	9.8	14.3	26.6	42.8	63.0
100	15	—	2.9	5.3	8.6	12.7	24.0	39	58
100	20	—	2.6	4.7	7.7	11.5	22.0	36	54

Set Pressure, psig	Length. ft	Type L Copper Tubing Outer Diameter (OD), in.							
		3/8	1/2	5/8	3/4	7/8	1-1/8	1-3/8	1-5/8
100	25	—	—	4.3	7.1	10.6	20.3	33.7	50.7
100	30	—	—	4	6.7	9.9	19.0	31.7	48.0
100	40	—	—	3.5	5.9	8.9	17.1	28.6	43.6
100	60	—	—	2.9	4.9	7.4	14.5	26.3	37.6
100	100	—	—	2.4	3.9	5.9	11.6	19.7	30.5

SI Conversions: kPa = psig × 6.895; mm = in. × 25.4; kg/s = lb/min × 0.007559; m = ft × 0.3048

Table E-1 ***Pressure Relief Valve*** **Discharge Line Capacity (lb/min of air) of Various Discharge Line Lengths** ***(Continued)***

Set Pressure, psig	Length, ft	Type L Copper Tubing Outer Diameter (OD), in. 3/8	1/2	5/8	3/4	7/8	1-1/8	1-3/8	1-5/8
100	160	—	—	—	3.1	4.7	9.4	16.0	24.8
100	250	—	—	—	—	3.8	7.6	13.0	20.2
150	5	—	5.3	9	14.3	20.5	36.5	57.2	82.6
150	10	—	4.4	7.6	12.2	17.8	32.6	52.0	76.1
150	15	—	3.8	6.7	10.9	16.0	29.7	48.0	73.9
150	20	—	3.4	6.1	9.9	14.6	27.5	44.8	73.9
150	25	—	3.1	5.6	9.1	13.6	25.7	42.2	63.1
150	30	—	2.9	5.2	8.5	12.7	24.2	40	60.1
150	40	—	—	4.6	7.6	11.3	21.9	36.4	55.1
150	60	—	—	3.8	6.4	9.6	18.7	31.5	48.0
150	100	—	—	3.0	5.1	7.7	15.1	25.6	39.5
150	160	—	—	—	4.1	6.2	12.2	20.9	32.3
150	250	—	—	—	3.3	5.0	10.0	17.0	26.5
200	5	3.1	6.2	10.7	16.6	23.7	42.1	65.8	94.7
200	10	—	5.2	9.1	14.4	20.8	38.1	60.5	88.2
200	15	—	4.5	8	13.0	19.0	35.1	56.3	82.8
200	20	—	4.1	7.3	11.9	17.5	32.6	52.9	78.3
200	25	—	3.6	6.7	11.0	16.2	30.7	50.0	74.5
200	30	—	3.5	6.3	10.2	15.3	29.1	47.6	71.2
200	40	—	3.1	5.6	9.2	13.8	26.4	43.6	65.7
200	60	—	—	4.7	7.8	11.7	22.7	40.5	57.8
200	100	—	—	3.7	6.2	9.4	18.4	31.2	47.9
200	160	—	—	3.0	5.0	7.6	13.6	25.5	39.5
200	250	—	—	—	4.1	6.2	12.2	20.9	32.5
250	5	3.5	7.1	12.1	18.8	26.8	47.5	73.9	106.3
250	10	—	6.0	10.4	16.5	23.9	43.3	68.5	99.6

Set Pressure, psig	Length, ft	Type L Copper Tubing Outer Diameter (OD), in. 3/8	1/2	5/8	3/4	7/8	1-1/8	1-3/8	1-5/8
250	15	—	5.3	9.3	14.9	21.8	40.1	64.2	94.1
250	20	—	4.8	8.5	13.7	20.2	37.5	60.6	89.4
250	25	—	4.4	7.8	12.7	18.9	35.4	57.5	85.4
250	30	—	4.1	7.3	12.0	17.7	33.6	54.9	81.8
250	40	—	3.4	6.6	10.8	16.1	30.6	50.5	75.9
250	60	—	—	6.0	9.1	13.7	26.5	44.2	67.1
250	100	—	—	4.4	7.3	11.1	21.7	36.5	55.9
250	160	—	—	3.5	5.9	9.0	17.7	30.1	46.4
250	250	—	—	—	4.8	7.3	14.5	24.7	38.2
300	5	4.0	8.0	13.5	21	29.8	52.6	81.8	117.1
300	10	—	6.8	11.7	18.6	26.8	48.4	76.3	110.7
300	15	—	6.0	10.5	16.9	24.6	45.0	71.8	105.0
300	20	—	5.4	9.6	15.5	22.8	32.2	68.0	100.1
300	25	—	5.0	9.0	14.5	21.4	39.9	64.7	95.8
300	30	—	4.7	8.4	13.6	20.2	38.0	62.0	92.1
300	40	—	4.2	7.5	12.3	18.3	34.8	57.2	85.7
300	60	—	3.5	6.3	10.5	15.7	30.3	50.3	76.1
300	100	—	—	5.1	8.4	12.7	24.8	41.7	63.8
300	160	—	—	4.1	6.8	9.3	20.3	34.5	53.1
300	250	—	—	3.3	5.5	8.4	16.6	28.4	43.9
350	5	4.4	8.9	14.9	23.1	32.8	57.7	89.6	128.5
350	10	3.6	7.6	13.1	20.6	29.6	53.3	83.9	121.1
350	15	3.2	6.7	11.8	18.7	27.3	49.8	83.9	115.6
350	20	—	6.1	10.8	17.3	25.4	46.8	75.2	110.1
350	25	—	5.6	10.0	16.2	23.8	44.4	71.8	106
350	30	—	5.2	9.4	15.2	22.5	42.3	68.9	102

SI Conversions: kPa = psig × 6.895; mm = in. × 25.4; kg/s = lb/min × 0.007559; m = ft × 0.3048

Table E-1 *Pressure Relief Valve* Discharge Line Capacity (lb/min of air) of Various Discharge Line Lengths *(Continued)*

Set Pressure, psig	Length. ft	Type L Copper Tubing Outer Diameter (OD), in.								Set Pressure, psig	Length. ft	Type L Copper Tubing Outer Diameter (OD), in.							
		3/8	1/2	5/8	3/4	7/8	1-1/8	1-3/8	1-5/8			3/8	1/2	5/8	3/4	7/8	1-1/8	1-3/8	1-5/8
350	40	—	4.7	8.4	13.8	20.5	38.8	66.1	95.2	450	160	—	3.1	5.7	9.4	14.3	28.0	47.4	73
350	60	—	3.9	7.1	11.8	17.7	34.0	56.2	84.9	450	250	—	—	4.6	7.7	11.7	23.0	39.2	59
350	100	—	3.1	5.7	9.5	14.3	28.0	46.9	71.6	500	5	5.7	11.3	18.9	29.1	41.3	72.4	112.1	161
350	160	—	—	4.5	7.9	11.7	22.9	38.8	59.7	500	10	4.8	9.8	16.8	26.3	37.8	67.5	105.9	153
350	250	—	—	3.7	6.2	9.5	18.8	32.0	49.5	500	15	4.2	8.8	15.2	24.2	35.1	63.5	100.6	146
400	5	4.8	9.7	16.3	25.1	35.7	62.7	97.2	139.3	500	20	3.8	8.0	14.1	22.5	32.8	60.2	96.1	141
400	10	4.0	8.3	14.3	22.5	32.4	58.1	91.4	132.1	500	25	3.5	7.4	13.1	21.1	31.0	57.3	92.1	135
400	15	3.5	7.4	12.9	20.6	29.9	54.4	86.5	126.0	500	30	3.2	6.9	12.3	20.0	29.4	54.8	88.6	130
400	20	—	6.7	11.9	19.1	27.9	51.4	82.3	120.7	500	40	—	6.2	11.1	18.1	26.9	50.7	82.4	123
400	25	—	6.2	11.9	19.1	27.9	51.4	82.3	120.7	500	60	—	5.2	9.5	15.6	23.3	44.5	73.6	111
400	30	—	5.8	10.4	16.8	24.9	46.5	75.6	111.8	500	100	—	4.2	7.6	12.7	19.1	37.0	61.9	94
400	40	—	5.2	9.3	15.2	22.7	42.8	70.1	104.6	500	160	—	3.4	6.2	10.3	15.6	30.5	51.5	79
400	60	—	4.4	7.9	13.1	19.6	39.9	62.1	93.6	500	250	—	—	5	8.4	12.7	25.1	42.7	65
400	100	—	3.5	6.4	10.6	15.9	31.0	52.0	79.2	550	5	6.1	12.1	20.2	31.1	44.1	77	119	171
400	160	—	—	5.1	8.8	13.0	26.2	43.1	66.3	550	10	5.1	10.5	18.0	28.2	40.4	72	113	163
400	250	—	—	4.2	7	10.6	20.9	35.6	55.0	550	15	4.5	9.4	16.4	26.0	37.5	68	107	156
450	5	5.2	10.5	17.6	27.1	38.5	67.5	104.7	150	550	20	4.1	8.6	15.1	24.2	35.3	64	103	150
450	10	4.4	9.1	15.6	24.4	35.1	62.8	98.7	143	550	25	3.7	8.0	14.1	22.8	33.3	61	98	145
450	15	3.8	8.1	14.1	22.4	32.5	59.0	93.6	136	550	30	3.5	7.5	13.3	21.5	31.6	59	95	140
450	20	3.5	7.4	13.0	20.8	30.4	55.8	89.2	130	550	40	3.1	6.5	12.0	19.6	28.9	54	89	132
450	25	3.2	6.8	12.1	19.5	28.6	53.1	85.4	125	550	60	—	5.6	10.3	16.9	25.1	47.9	79	119
450	30	—	6.4	11.4	18.4	27.2	50.7	82.1	120	550	100	—	4.5	8.3	13.5	20.5	40.0	67	101
450	40	—	5.2	10.2	16.7	24.8	46.8	76.4	114	550	160	—	3.6	6.7	11.2	17.4	33.1	56	85
450	60	—	4.8	8.7	14.3	21.5	41.1	67.9	102	550	250	—	3.0	5.4	9.1	13.8	27.2	46.2	71
450	100	—	3.8	7.0	11.6	17.5	34.0	56.9	87										

SI Conversions: kPa = psig × 6.895; mm = in. × 25.4; kg/s = lb/min × 0.007559; m = ft × 0.3048

(This appendix is not part of this standard. It is merely informative and does not contain requirements necessary for conformance to the standard. It has not been processed according to the ANSI requirements for a standard and may contain material that has not been subject to public review or a consensus process. Unresolved objectors on informative material are not offered the right to appeal at ASHRAE or ANSI.)

INFORMATIVE APPENDIX F EMERGENCIES IN REFRIGERATING MACHINERY ROOMS

This standard specifies refrigerating *machinery rooms* under some conditions to reduce risks from large *refrigerating systems* and large amounts of *refrigerant*. One purpose of the requirements is to warn of emergencies in the refrigerating *machinery room*. The *refrigerant detector* required by Section 8.11.5 triggers alarms inside and outside the refrigerating *machinery room*. Signage warns refrigeration technicians and bystanders not to enter when the alarm has activated.

This appendix provides guidance on integrating the minimum emergency warning and training requirements of this standard with measures often taken in occupational health and safety programs.

The requirements in the standard provide minimum protection to help prevent injury from refrigerating *machinery room* accidents. Minimal conformance to the standard's specifications does not necessarily facilitate the convenient handling of incidents in the room. For example, if only the minimum protective steps are taken, refrigeration technicians may not reenter the *machinery room* after an alarm has sounded (to silence the alarm and repair any damage) without calling on the services of emergency responders (generally the local hazardous materials team). Many other approaches are possible, especially in facilities that prepare sophisticated emergency response plans.

F1. ALARM LEVELS

A *refrigerant* level above the *OEL* activates the alarms required by Section 8.11.5. If personnel working in the refrigerating *machinery room* are not provided with and trained to use respiratory protection equipment appropriate for the *refrigerant* (such as canister respirators or self-contained breathing apparatus), they must leave the room immediately. Presence of *refrigerant* above the *OEL* does not by itself signal an emergency. Many routine service operations can create such levels. Local or national regulations often prescribe that steps be taken to protect the health and safety of personnel working in the *machinery room* when *refrigerant* concentrations rise above the *OEL*.

In a more sophisticated facility, with appropriate training and other measures *specified* by local regulations, refrigeration technicians might use this alarm as a signal to don respiratory protection. Evacuation of the *machinery room* may not be necessary, although warning bystanders not to enter still is. Selection of the proper respiratory protection for the particular situation may require additional information (e.g., whether or not the *refrigerant* concentration is above the *immediately dangerous to life or health* [*IDLH*] level).

Note that donning respiratory protection is a last-resort option under most industrial hygiene regimens. It is preferable to provide *engineering controls* to reduce *refrigerant* concentrations to tolerable levels. The *refrigerant detector* required by Section 8.11.5 activates the *machinery room* ventilation automatically. In many cases, this may be entirely adequate to reduce the concentration, and respiratory protection may not be needed. (An alarm silence switch is useful for situations where personnel are to remain working in the room.)

F2. ALTERNATE REFRIGERANT LEVEL MEASUREMENTS

The required alarms signal only that *refrigerant* was detected at concentrations above the *OEL*. Some facilities may find it useful to have multiple levels of alarm or to provide an instrument that indicates the actual *refrigerant* level (digital readout in parts per million of *refrigerant*). Selecting proper respiratory protection for technicians or other responders, as mentioned above, is one reason. This is perfectly acceptable, provided that the additional alarms or indicators are clearly distinguished from the main alarm. Bystanders should not be confused by the alarm arrangements.

The main alarm must be a manual-reset type as required per Section 8.11.5. It is unwise to rely on automatic detectors to announce that an event is over. A technician could not distinguish between an alarm that reset when the *refrigerant* concentration dropped (e.g., because ventilation fans controlled the incident) and one that reset because the *refrigerant detector* was damaged. In the latter case, anyone entering the refrigerating *machinery room* might be entering a hazardous area. Alarms or indicators intended to communicate current conditions inside the refrigeration *machinery room* may, of course, be automatically resetting.

F3. REENTRY INTO REFRIGERATING MACHINERY ROOMS

Reentering an area during an emergency requires sophisticated equipment and training; many national and local regulations govern such activities. Prepositioning emergency response equipment (e.g., self-contained breathing apparatus) should be done only by arrangement with emergency responders, and any prepositioned equipment should be clearly labeled for use by trained personnel only. Doing otherwise invites unauthorized use (or vandalism) by untrained personnel, with dangerous consequences.

Facilities should note, however, that the alarms required in this standard annunciate not that an emergency is occurring but that an abnormal situation is occurring. It may be acceptable for trained personnel to enter the refrigerating *machinery room* to investigate the situation, repair minor leaks, reset alarms tripped in error, etc. Any personnel required to enter should be provided with appropriate personal protective equipment (especially respiratory protection, if needed) and should be trained to recognize an emergency situation requiring professional emergency response.

F4. EXAMPLE EMERGENCY PROCEDURES

As an example (and there are many other possibilities), consider a facility that wishes to use its own technicians to handle minor problems in the refrigerating *machinery room*. The facility

a. provides the *refrigerant* alarm required by Section 8.11.5, along with signage warning "Authorized Personnel Only. Stay Out When Refrigerant Alarm Sounds; Call Facilities Management Immediately." This alarm triggers at the *OEL*.

b. provides a digital readout of the current *refrigerant detector* reading outside the refrigerating *machinery room*. A sign distinguishes the current-reading indicator from the alarm-activation indicator required by Section 8.11.5.

c. provides the refrigeration technicians with appropriate respiratory protection suitable for use in an atmosphere containing *refrigerant* in concentrations below the *IDLH*, in accordance with all applicable national and local regulations.

d. defines as "incidental" any *refrigerant* release that is not producing levels above the *IDLH* in the *machinery room*. (The ventilating system will render many potential releases incidental.)

e. trains the technicians to leave the refrigerating *machinery room* when the *refrigerant* alarm sounds. After donning appropriate respiratory protection (if necessary), they may reenter the *machinery room* to close valves, fix leaks, shut off alarms, etc., *if and only if* the current *refrigerant* level is below the *IDLH*. That is, technicians may reenter the room if the *refrigerant* release is incidental. If the level exceeds the *IDLH*, or the problem seems uncontrolled in the sense that it may unpredictably worsen or require a team of technicians to fix, they are to leave and call for emergency responders.

f. coordinates emergency procedures with the local emergency response agencies in advance.

None of these steps contradicts the requirements of the standard, but the additional procedures significantly aid the facility's efforts to handle minor maintenance problems safely.

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INFORMATIVE APPENDIX G
ADDENDA DESCRIPTION INFORMATION

ANSI/ASHRAE Standard 15-2019 incorporates ANSI/ASHRAE Standard 15-2016 and Addenda a, b, c, d, e, f, h to ANSI/ASHRAE Standard 15-2016. Table G-1 lists each addendum and describes the way in which the standard is affected by the change. It also lists the ASHRAE and ANSI approval dates for each addendum.

Table G-1 Addenda to ANSI/ASHRAE Standard 15-2016

Addendum	Sections Affected	Description of Change*	ASHRAE Standards Approval	ASHRAE Tech Council	ANSI Approval
a	3; 2.3; 7.2, 7.4, 7.5; 8.11, 8.12; 9.1, 9.7; Appendix A, Appendix C,	Removes requirements related to Ammonia, and refers to ANSI/ IIAR 2.	6/23/2018	6/27/2018	6/28/2018
b	7.2.2, 7.5.3	Defines low probability pumps and provides requirements pertaining to their use, removes requirements for high-flammability refrigerants and industrial occupancies/refrigerated rooms pertaining to floor area per occupant.	6/23/2017	6/28/2017	6/29/2017
c	3; 8.11; Appendix F	Coordinates with Standard 34 to use OEL values rather than TLV-TWA.	6/23/2017	6/28/2017	6/29/2017
d	7.5.2, 7.6 (new); 9.13.1	Incorporates requirements for Class 2L refrigerants used in human comfort applications	9/14/2018	9/28/2018	10/23/2018
e	3; 5.3; 7.5.1.7	Identifies which requirements need to be met when changing refrigerants within the same refrigerant class.	6/23/2018	6/27/2018	6/28/2018
f	8.12; 9.7.9.3	Eliminates requirements for machinery rooms that are more restrictive than what is required for Group H occupancies under the IBC which are far more hazardous.	1/28/2017	2/1/2017	2/2/2017
h	3; 7.4; 8.11, 8.13 (new); 9.7.8	Incorporates requirements for Class 2L refrigerants used in machinery rooms	9/14/2018	9/28/2018	10/1/2018

* These descriptions may not be complete and are provided for information only.

POLICY STATEMENT DEFINING ASHRAE'S CONCERN FOR THE ENVIRONMENTAL IMPACT OF ITS ACTIVITIES

ASHRAE is concerned with the impact of its members' activities on both the indoor and outdoor environment. ASHRAE's members will strive to minimize any possible deleterious effect on the indoor and outdoor environment of the systems and components in their responsibility while maximizing the beneficial effects these systems provide, consistent with accepted Standards and the practical state of the art.

ASHRAE's short-range goal is to ensure that the systems and components within its scope do not impact the indoor and outdoor environment to a greater extent than specified by the Standards and Guidelines as established by itself and other responsible bodies.

As an ongoing goal, ASHRAE will, through its Standards Committee and extensive Technical Committee structure, continue to generate up-to-date Standards and Guidelines where appropriate and adopt, recommend, and promote those new and revised Standards developed by other responsible organizations.

Through its *Handbook*, appropriate chapters will contain up-to-date Standards and design considerations as the material is systematically revised.

ASHRAE will take the lead with respect to dissemination of environmental information of its primary interest and will seek out and disseminate information from other responsible organizations that is pertinent, as guides to updating Standards and Guidelines.

The effects of the design and selection of equipment and systems will be considered within the scope of the system's intended use and expected misuse. The disposal of hazardous materials, if any, will also be considered.

ASHRAE's primary concern for environmental impact will be at the site where equipment within ASHRAE's scope operates. However, energy source selection and the possible environmental impact due to the energy source and energy transportation will be considered where possible. Recommendations concerning energy source selection should be made by its members.

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